GPS monitoring station at Cape Roberts, Antarctica operates year-round with solar power and a large bank of Deka Solar Gel Batteries.

Photo Courtesy of UNAVCO

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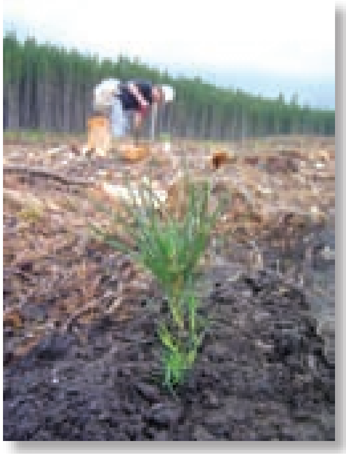
Clockwise from bottom left: Gary Reysa; Curt Blank; Jennifer & Lance Barker; Donald Dunklee; Jonathan Clark

On the Cover

Home Power **tips its hat to the many people whose vision and ingenuity have fueled a clean energy revolution.**



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Change... Then & Now

Twenty years ago, solar, wind, and hydro-electric technologies made it possible for people to live beyond the reach of the utility grid and harvest renewable energy to power both their homes and lives. With this time-tested history in hand, over the last decade, renewable energy has come to town. Today, on-grid solar-electric and solar hot water systems are becoming a common sight in suburban and urban locations across the country. And each of these systems is an integral part of a movement that is fundamentally reframing the future of energy.

When Richard and Karen Perez launched *Home Power* in 1987, their mission was to change the way people generate and use energy, one rooftop at a time. And for two decades, we've continued to broadcast this message, loud and clear. Over the years, *Home Power* has become the editorial venue for homeowners, business owners, and renewable energy professionals to exchange equipment, design, installation, and system performance experiences. This information exchange has helped create an industry with not only cutting-edge technology, but perhaps more importantly, a common goal: reducing the use of polluting fossil fuels and replacing this generation capacity with the infinite supplies of renewable energy that surround us.

The cost of energy from finite fuels like coal, natural gas, and oil will continue to increase as deposits dwindle and become more expensive to extract. The inevitability of renewable sources dominating fossil-fuel-based generation is a given, and the how and when are starting to become clear as well. Today, industrial-scale wind turbines produce electricity at a price that's competitive with coal-fired plants. Over the next two decades, energy generated with solar technologies will in all likelihood compete head-to-head with natural-gas-fired electricity generation. And just like current wind technologies, do so without polluting the environment.

The growth and change in renewable energy to date has been nothing short of spectacular. And we're just getting warmed up. The next twenty years are going to be good ones.

Think About It...

Truth is like the sun. You can shut it out for a time, but it ain't goin' away.

—Elvis Presley

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Ask the EXPERTS!

Mercury in CFLs

On the advice of your magazine, I replaced all but the most unused incandescent lightbulbs in my house with compact fluorescent bulbs (CFLs). My electric bill has dropped about 15 percent, but I'm concerned about a report I read about mercury in CFLs. The report said that when CFLs are disposed in landfills, they will leach mercury, which eventually winds up in the watershed, poisoning the water. Does using CFLs offset enough mercury emissions from coal-burning power plants to make their use worthwhile? Is there a company that will recycle my old CFLs?

Trent Miller • Tinley Park, Illinois

Kameleon007/iStockphoto

This is a question that's worth considering from several different perspectives. One is the amount of mercury in a CFL compared to any number of other household items containing mercury. The second is the amount of mercury emissions displaced by the use of CFLs. And the third is how to deal with disposing of CFLs (or any mercury-containing item) in an environmentally responsible manner.

An average-sized CFL bulb contains approximately 4 milligrams (mg) of mercury, an amount about equal in size to the period at the end of this sentence. Standard 4-foot-long T12 fluorescent tubes contain up to 21 mg of mercury and modern T8 tubes with electronic ballasts can contain about 10 mg per tube. By comparison, watch batteries contain as much as 25 mg—the equivalent of about six CFLs. Older home thermostats contain from 500 mg to 2 grams of mercury, or the amount in 125 to 400 CFLs.

So, while not downplaying the risks of mercury exposure, the amount of mercury in a CFL is minimal compared to other products that people typically use (information from the North Carolina Department of Environment and Natural Resources).

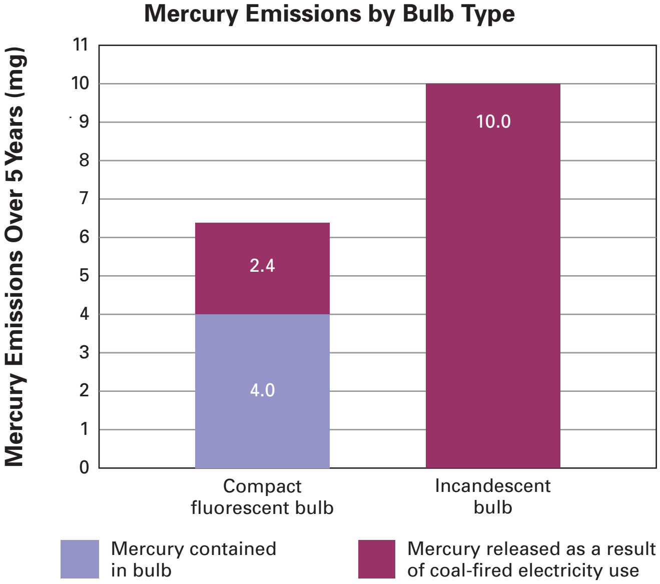
The greatest source of mercury in our environment comes from burning coal, the most common fuel used in the United States to generate electricity. A CFL uses 75 percent less energy than an incandescent lightbulb and lasts at least six times longer, so the mercury emissions that result from the coal-fired electricity used to power it are considerably lower. If you're relying on coal-fired electricity, over a bulb's lighting lifetime, using a CFL produces an additional 2.4 mg of mercury emissions. Contrast this with the 10 mg of emissions produced by using a conventional incandescent bulb over the same five-year life span. Incandescents produce more mercury contamination than CFLs, and this is only gaseous emissions from a typical coal-fired power plant. You also need to consider the mercury leachate from coal mine waste and fly ash disposal. More coal needed for electricity translates into more coal mined—resulting in more mercury pollution.

Recycling and recovery programs exist for mercury in thermostats and thermometers, but residential CFL recycling programs are relatively new. To find a CFL recycling center near you, go to www.earth911.org (or call 800-CLEAN-UP for an automated hotline). Enter your zip code, and select Go. Then click on Household Hazardous Waste and Compact Fluorescent Lightbulbs. The site will identify the closest residential mercury recycling facility, mail disposal method, or hazardous waste facility. You can also click on the link for Mercury Containing Items.

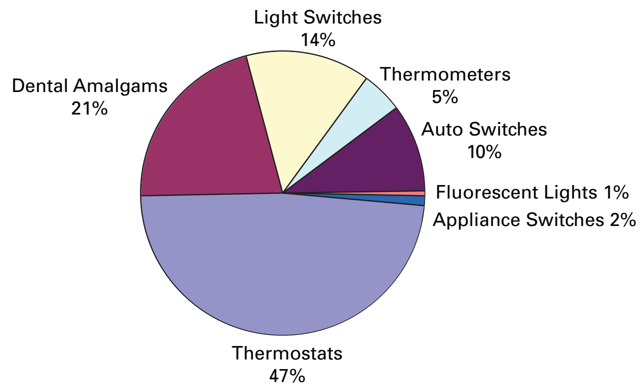
If a CFL or linear fluorescent tube breaks, air out the room and sweep up (don't vacuum) the glass shards. Place the CFL in a sealable, plastic bag and dispose of it at your local household hazardous waste collection site. If your local collection site cannot accept CFLs, seal the CFL in a plastic bag and place it with your regular trash. However, if your waste agency incinerates its garbage, you should search a wider geographic area for proper disposal options. Never send a CFL or other mercury-containing product to an incinerator.

Dave Muhly • Sierra Club, Appalachian Region

Mercury Emissions by Bulb Type



Mercury Found Around the Home



(continued on page 14)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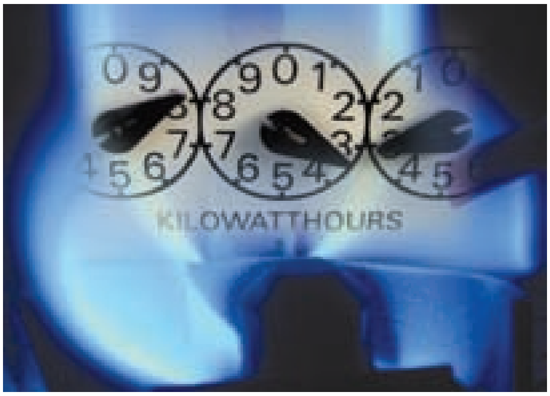
Choosing a Water Heater

I want to purchase a new tank-style hot water heater, and would like to eventually install a solar hot water system, but I'm confused about which type to buy now. Although I have asked numerous professionals and researched articles in magazines and on the Net, I have been unable to find a clear answer on which type of tank is the most energy efficient—electric, power-vented gas, or standard gas?

Tim O'Connor • Ottawa, Canada



Gas water heaters with a flue in middle of the tank have more standby heat loss than an electric heater with the same amount of jacket insulation. This makes electric water heaters a more efficient backup for a solar hot water system, and they are especially attractive if the electricity cost is less than, equal to, or only slightly more than gas. In computing costs, keep in mind that electric water heaters are rated at 95 percent efficiency, while conventional gas heaters are rated at 65 percent. Although some power-vented tank type water heaters claim to have a 90 percent efficiency, none appear on the Gas Appliance Manufacturers Association's list of tax-credit eligible heaters, which specifies a minimum energy factor rating of 80 percent (see www.gamanet.org).

The initial cost of the water heater also can be a factor. Electric and conventional gas tank-style water heaters are relatively less expensive, while power-vented, instantaneous, and heat-pump water heaters can be significantly higher in cost—particularly so when the installation costs are included.

Chuck Marken • *Home Power*

Grid-Tie Connection

I have read many of your articles detailing the design and installation of solar-electric systems and am very inspired to start planning one of my own. I want to mount PV modules on my garage because it faces due south and has an excellent pitch. However, it's about as far as you can get from my home's main breaker panel. This means that I would have to run an expensive and, more importantly, a long and difficult conduit run.

I've never understood why you can't just connect the inverter directly to the closest 120-volt household outlet that you can find. Of course, that would mean using a 120-volt inverter, such as the SWR1800U from SMA America. Would I be making a mistake by connecting it to the closest outlet I can locate?

Jakob Speksnijder • West Chester, Pennsylvania

From a strictly electrical perspective, there is nothing incorrect or inherently unsafe about making a grid-tie inverter's AC connection into an AC outlet circuit. But from a *National Electrical Code (NEC)* viewpoint, it is not acceptable. There also might be some performance problems caused by connecting a grid-tie inverter this way.

Where the inverter is connected really makes no difference to the electrons. But the *NEC* requires that a grid-tie inverter be connected to its own dedicated wiring circuit—connecting it to a 120 VAC outlet circuit does not meet this requirement.

One potential problem with using the outlet circuit for the inverter has to do with the possibility of excessive voltage drop in the existing wiring when the grid-tie inverter is operating at high power levels. Underwriters Laboratories Standard 1741 requires the operation of a grid-tie inverter to fall within a very tight voltage window to satisfy safety and power quality requirements. Often a long wire run like you described should be installed with a larger wire size than the #12 cable typically used in home outlet circuits. The heavier-gauge wiring will have a higher current rating, minimize voltage drop, and ensure optimal inverter performance.

In addition, if the wiring feeding the outlet circuit were heavily loaded with appliances, the AC voltage might drop below the grid-tie inverter's lower voltage limit, especially when an appliance starts up. This could result in the inverter frequently shutting off and restarting, which will reduce the system's performance and possibly affect inverter reliability over time.

Finally, many utilities will require an externally mounted AC inverter disconnect located nearby the service entrance and utility meter. With the inverter located in the garage and connected to an AC outlet, this would not be possible. If your garage has a subpanel, it might be possible to tie into a breaker there, depending on local utility requirements.

Christopher Freitas • OutBack Power Systems Inc.

Solar Hot Air Calculation

I enjoyed reading the article you published on solar air heating ("Making Sense & Dollars of Solar Hot Air Collectors," *HP118*), as well as the process that you established for evaluation. But how do you account for the amount of time during the heating season that clouds limit the effectiveness of the unit? Or account for the amount of time that the unit is capable of heating, but there is no heat demand from the house—when the thermostat is not calling for heat?

These two critical questions will severely impact any benefit calculation for payback, since it will reduce the amount of time that can be counted as providing a benefit. I welcome your thoughts.

Mark Yerkes • Lancaster, Pennsylvania

F-Chart Solar Systems Analysis Software (www.fchart.com) uses local data from a nearby weather station—in my case Medford, Oregon—and models when the house does and does not need heat. In my article, under the "Tweaking the Model" section, I noted that the model was presuming a call for heat in early morning in the summer, which I would greatly regret later in the day. To account for this, I reduced the estimated percentage of heat the system would provide from 28 percent to 21 percent of the total annual heating load. If you want specifics for your particular case, you'll have to run the F-Chart model.

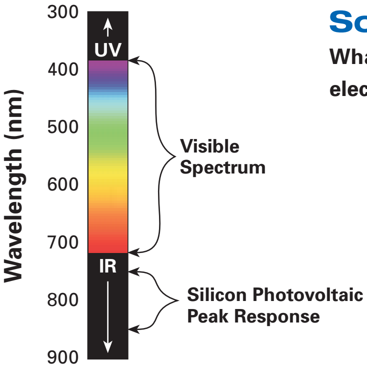
Since I don't own a copy of F-Chart, I cannot give a detailed description of the software. I chose it because my solar consultant, whom I trust, uses it. The manual is available at the F-Chart Web site, but doesn't elaborate upon the underlying assumptions that go into the model. F-Chart accepts a lot of user-defined parameters, including local weather conditions, insulation of building envelope, etc. These specific parameters must be specified to determine some of the answers you seek, such as savings per square foot of collector (I chose to evaluate savings in dollar costs for the system). As for the efficiency of the collector, the model makes assumptions. As to what they are, I don't have a clue, but I'm confident they are based on tested industry norms. Some of Chuck Marken's earlier articles (cited under "Related Reading" in my article) go deeper into the matters of collector efficiency.

Andy Kerr • Larch Company

Solar Spectra

What wavelengths of sunlight does a solar-electric cell actually use to generate electricity? Have there been attempts to increase the efficiency of the cells?

Austin Kelly • Downpatrick, Ireland



A typical silicon solar cell absorbs light from almost the entire solar spectrum, although only a select portion will start electrons flowing. Light in the far-infrared range, at a wavelength of about 12,000 angstroms (1,200 nm), penetrates too deeply into the silicon and has little effect in producing electricity. Most of the photons in the shorter wavelengths, such as the violet portion, enter too shallowly to produce any electricity. Shorter wavelengths that do penetrate mostly generate heat, which has an adverse effect on the cell's performance. Peak response in a silicon solar cell occurs between 7,000 and 8,500 angstroms, just beyond the visible spectrum and where the infrared begins.

Many improvements made in silicon solar cells over the last fifty years have significantly increased their efficiency. These improvements include lowering electrical resistance so more energized electrons can flow to points of collection; decreasing reflectivity; increasing light absorption; and improving the surface area of cells to allow for more energized electrons to reach the metallic contacts, where they become useful. The ideal solar cell would be an alloy with multiple materials configured to optimally respond to each portion of the solar spectrum. Multispectrum solar cells are not commercially available, but like many other solar technologies, are being researched with hopes for the future.

John Perlin, Director of Solar Energy Implementation • University of California, Santa Barbara

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Courtesy Zeke Yewdall

Solar Installation Footprint

I am the chief engineer for a company that designs and installs grid-tied residential solar-electric systems in Colorado. We use a lot of nonrenewable fossil fuel driving back and forth to installations, and I've been wondering if we are really part of the solution. So I did a quick carbon emissions analysis. Here's what I found:

- For each system, our main salesperson and I each drive out for a site visit. Each of us average 75 miles at 28 mpg for each round-trip. That roughly translates into 100 pounds of carbon dioxide (CO_2) emitted.
- We bring our large box truck to the site on two separate days for the installation; 60 miles, two trips at 10 mpg: about 230 pounds of CO_2.
- Support vehicles for the installation (installation crew members driving separately, second install vehicle, etc.); 70 miles, four trips at 25 mpg: about 220 pounds of CO_2.
- Our electrician visits three times (post the permit, complete the wiring, and inspect the system); 120 miles each trip at 22 mpg: about 320 pounds of CO_2.
- To this total, we can add another 50 percent to account for other transportation, such as getting parts, inspectors' travel: 435 pounds of CO_2.
- Then add another 100 KWH of utility electricity use for computer/phone/office use related to the project: about 200 pounds of CO_2.
- Total CO_2 emissions incurred in selling and installing a grid-tied PV system: 1,500 pounds.

Our average system size is about 4 KW, which generates a little more than 400 KWH a month here in Colorado. Each KWH of utility electricity used generates about 2 pounds of CO_2 (since utility electricity in the Boulder area is largely coal-based). So, in less than two months, the PV system has generated enough electricity to avoid the carbon emissions incurred in installing it. Compared to the one to five years it takes to pay back the energy used to manufacture PV modules, two months more isn't too bad in the big picture. Not to mention that the system itself will generate clean, carbon-free electricity for 25 years or more.

We can certainly try to decrease emissions by reducing the number of vehicles needed and using biofuels where possible. (In the summer, we run biodiesel in the big box truck and in one of the small trucks,) But it's nice to know that even with all this fuel usage, we are still a big part of the solution to the planet's CO_2 overload.

Zeke Yewdall, Sunflower Solar • Boulder, Colorado

Decentralize

Ever since watching the movie *Who Killed the Electric Car?,* I have seen a trend. Concerning electric-only motor vehicles of all types, I have found restrictions on use and the lack of availability in the United States evolving into a clear pattern, including in recent *Home Power* articles on electric cars (*HP117*) and electric bikes (*HP118*), and elsewhere. In *The New York Times*, NYC's new restrictions on pedicabs are bad enough, but to specify bans on electric assist pedicabs was over the top.

It seems the advantages of electric vehicles, specifically electric-only, as an option will be restricted in the United States. Electric-only vehicles are extremely cheap to run and maintain—and a threat to the status quo of centralization.

We have missed Jefferson's vision of free independent yeoman farmer-citizens. Can we have decentralized energy production at home by a free citizenry?

I believe the most important and revolutionary factor slowing our access to electric-only transportation is the possibility of the *decentralization* of "fuel" sources such as homegrown PV, hydro, and wind. This approach is contrary to most government-subsidized trends toward biofuels, hydrogen, and ethanol. The quickening of the transition to a greater sustainable and decentralized system brings with it increasing awareness of the dependence of a centralized petrol energy system (including hybrid petrol-electric) sustained by war, blood, and an increasingly authoritarian government.

We have missed Jefferson's vision of free independent yeoman farmer-citizens. Can we have decentralized energy production at home by a free citizenry?

Richard Paolillo • Winthrop, New York

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Breaking Barriers

It has come to our attention that certain companies are hiring female models to sell their products at conferences instead of, or in addition to, sending their employees. As a group of educated and empowered women working in the solar field, you can imagine our shock and dismay in learning this. The larger question becomes: why don't these companies hire qualified female employees if they want to show true representation of both genders? The number of qualified and educated women in the field is growing daily. Women are breaking through the barriers of working in a traditionally male field with ease.

Women are breaking through the barriers of working in a traditionally male field with ease.

The idea that a woman's role in this industry is to sell product through sex appeal is a demeaning mockery to everyone involved. Let's take the high road and establish roles for women that challenge the status quo of the male majority. This type of marketing went out of style decades ago, and should be as obsolete as the dinosaurs that made the fossil fuels we aim to replace.

The Solar Sisters of SEI:
Carol Weis, Justine Sanchez,
Laurie Stone, Sandy Pickard,
Kathy Fontaine, Soozie Lindbloom,
Rachel Ware, Laura Walters,
Kim Derhammer, and Kathy Swartz •
Carbondale, Colorado

Window Treatment

In *HP118*, I saw two references to dealing with window heat loss. There is an excellent product for this that I have been using for 25 years in my off-grid, 2,500-square-foot, passive solar home that you may want to investigate—removable acrylic windows.

An outfit named Magnetite (www.magnetite.com) supplies magnetic strips that slip over the edge of 3/32-inch Plexiglas. You simply cut it on site (very easy—just score and snap), and stick it onto metal strips that you have attached around the window frame.

I have put them up each fall here in Rhode Island, and they stop all drafts falling off the glass in my Andersen windows. I have never done a scientific test, but when I put my hand on my R-30 wall and then on the Plexiglas next to it, they feel nearly the same temperature, with the outside temperature at 0°F. Try that with any glass, even Thermopane, exposed to that temperature.

Plexiglas scratches easily, so it needs to be treated with care. The company has changed the metal strips that attach to the window frame to a small angle that screws to the inside edge. I prefer the old self-stick metal strips that went on the face of the frame, but I think they had problems with the glue, so they changed. Check it out. I will be specifying it in six low-energy homes I am going to build on the road frontage of my farm.

Ted Sanford • Exeter, Rhode Island

Diesel Doubts

Ray Holan's article comparing diesels and hybrids (*HP117*) was a good price-versus-payback comparison. An additional note should be added regarding diesel emissions and their health dangers.

If you believe a diesel vehicle may be better suited for you than a hybrid…take pains to look into the technology on that diesel.

Conventional diesel engines emit a fine particulate "soot," often including hundreds of different chemical elements, including sulfates, ammonium, nitrates, elemental carbon, condensed organic compounds, and even carcinogenic compounds and heavy metals, such as

arsenic, selenium, cadmium, and zinc. And much of that soot is less than 0.1 microns in size, which is small enough to penetrate the cells of the lungs and can cause long-term adverse health effects, including lung cancer.

Although great effort is being put into cleaning up diesel exhaust, very few diesel vehicles currently available in the United States have these new technologies. And none of the older diesels already on the roads have them.

We all now know about the evils of appliances on standby—the little red telltale light that says, "I'm still burning your money."

This makes almost the entire fleet of diesel vehicles on the road today a major health risk—to the people who drive them and to the people who breathe in their exhaust. (For more detail on this, see the Union of Concerned Scientists Web page—www.ucsusa.org/clean_vehicles/big_rig_cleanup/life-of-soot-diesel-pollution-emissions-and-health-effects.html.)

If you believe a diesel vehicle may be better suited for you than a hybrid, by all means, get the vehicle that is best for you. But take pains to look into the technology on that diesel to make sure you are not sacrificing public health in the name of fuel efficiency. And it's probably not a good idea to consider a *used* diesel vehicle at all—buy new.

Steve Jordan • Germantown, Maryland

Phantom Loads

I discovered your magazine about six months ago, and have become a most avid reader indeed! While I benefit from utility electricity, water, and gas all piped to my door, I have decided to see what I could do about reducing my energy consumption. Not "off grid," but "less grid," if you like. To that end, I recently bought one of the new generation of small plug-in electric energy meters, such

as you have recently featured. It has been a revelation! Electricity is leaking out all over the place. And in places that I—and maybe your readers—would not expect.

We all now know about the evils of appliances on standby—the little red telltale light that says, "I'm still burning your money." So we all make the extra effort to get up off our backsides at the end of the evening and turn off the appliance at its built-in switch, secure in the knowledge that, with the little red light off, the equipment is well and truly off, right? *Wrong!* Many appliances continue to use electricity even in this "supposedly off" state.

- If you have a computer that you can restart by a twitch of the mouse, press of the keyboard, or brief touch to the power button to bring it to life, chances are that it still uses electricity even in this state—mine burns 12 W.
- I have a lovely color laser printer. When it's not running, it goes into standby (78 W), and if left unused for a further 30 minutes, turns itself "off" (no lights or signs of life). *But even then,* it is secretly consuming 20 W!

Many appliances continue to use electricity even in the "supposedly off" state.

- I have a nice, new flat-screen plasma TV. With the standby light on, it draws 29 W. Press the main power button on the TV; the light goes out and the consumption drops to—wait for it—24 W. That's 24 W, 24/7.
- And here's a killer: a small digital TV receiver set that consumes 14 W when it's on and 14 W when it's off! Go figure.

Just the phantom loads I've mentioned here amount to almost 2 KWH per day! Then there are (or were!) the numerous wall-wart plug-in chargers, permanently plugged in and forgotten behind assorted heavy furniture, each snuffling a few watts apiece. In one case, the appliance the charger was designed

to feed was no longer in use at all! One trick here is to replace older, heavy transformer-based adaptors for modern, lighter-weight, switched-mode power supplies. More initial outlay, but lower energy consumption in the long run.

The lesson here is that for many electronic devices, only "unplugged" means "off." I have installed individually switched outlets where they can be accessed and encouraged my family to use them. I have put timer switches on TVs, computers, CD players, and the like to electrically unplug the devices at times when I never expect the items to be in use anyway. While we wait for manufacturers to catch up with the leading-edge thinking on standby power, it pays us all to be doubly aware of the background consumption of many of our electrical items.

Next time I go shopping for a new TV, I might just take my little electric gizmo with me, if only to see the surprise on the sales assistant's face when I ask if I can plug it in to my prospective purchase first!

Laurence Wilkins • United Kingdom

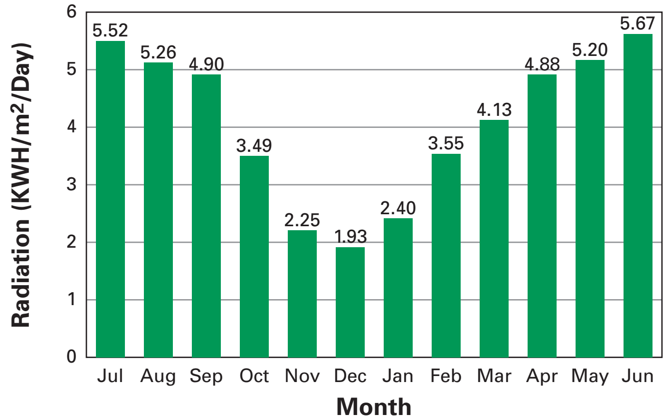
Solar Variation

I am responding to a letter from Jon A. Sharp entitled "Plenty of Sunshine" in the *Mailbox* section of *HP118.* I also live in New York State. Our home is about 16 miles east of Rochester, and 5 miles south of Lake Ontario. People often think of wind availability as varying on a micro-level. A similar type of variation can happen with solar resources. Due to a "lake effect" (excessive cloudiness and increased snow accumulation), we can have even less sun than the rest of the state. Our home is a passive solar design with PV, solar water heating, active solar

People often think of wind availability as varying on a micro-level. A similar type of variation can happen with solar resources.

Peak Sun-Hours: Rochester, New York*

* Approximately 10 miles west of Douglas's home in Penfield, NY



air heating, and a wind turbine, so I pay attention to the weather.

Over the past six years, we have averaged about three to four days of sun per month from November through February. The range is from two days per month in our worst year to eight days per month in our best year. During those four months, PV contributes minimally to our electricity production. For those four months, our 100-gallon, solar-heated water tank stays between 46°F and 60°F, even though I regularly remove the snow from the evacuated tubes. During the summer when there is abundant sun (for Rochester), the tank varies from 90°F to 150°F.

I suspect Jon and I experience a significant difference in solar availability even though we are in the same state. People considering renewable energy should look at their microenvironment to better estimate energy harvesting potential.

Douglas Stockman • Penfield, New York

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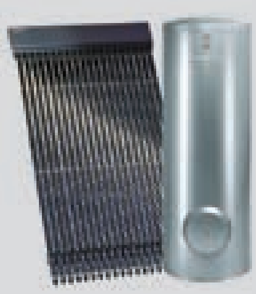

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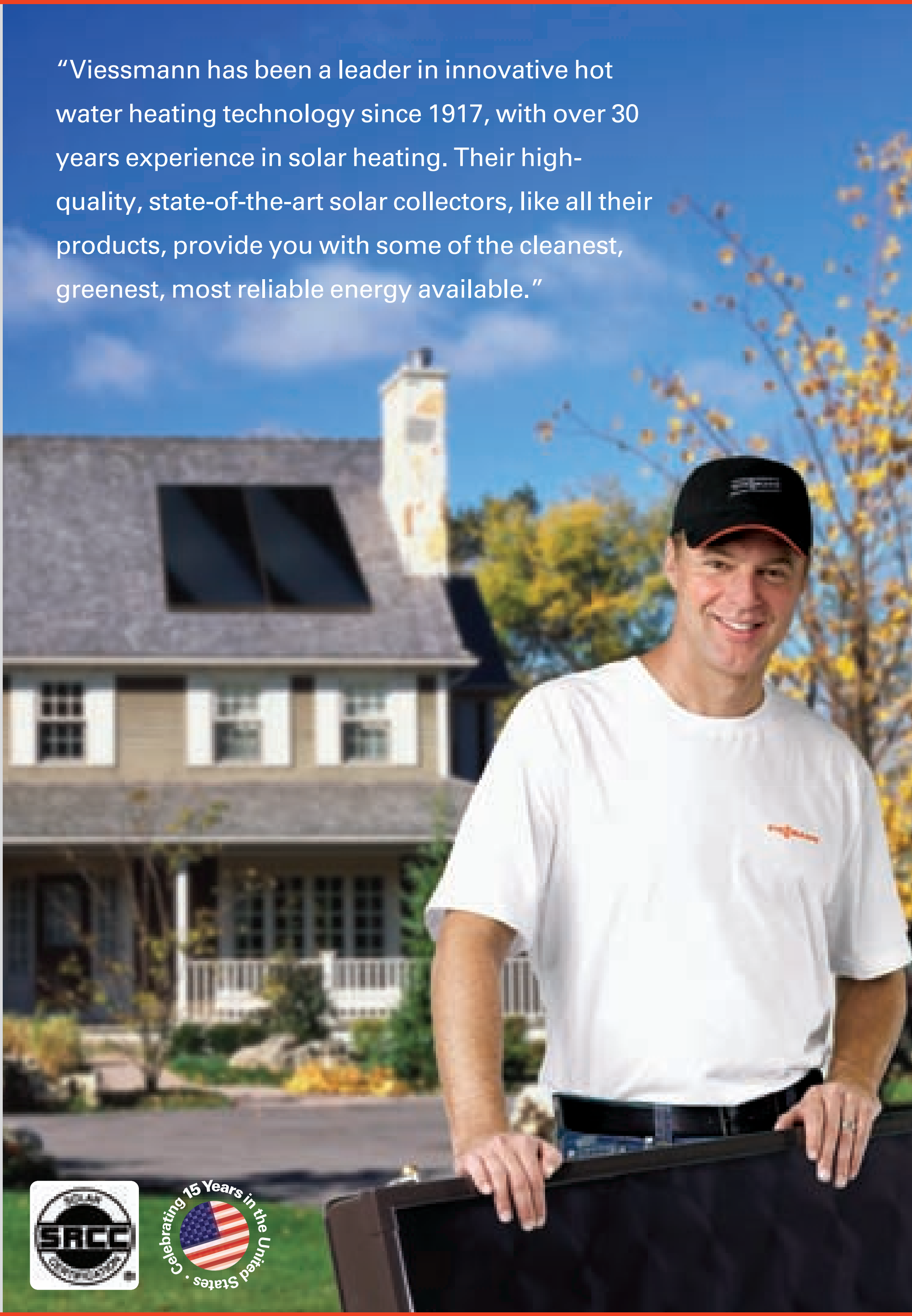

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TWENTY YEARS OF PEOPLE POWER

A Renewable Energy Reprise

by Joe Schwartz & Ian Woofenden

"There is more to *Home Power* than making electricity. It's easy for us to focus on a piece of hardware: what it does, how it works, and how much it costs. It's also easy to lose sight of the power that comes first—people power. The will to do, and the power to accomplish what we will."

—Richard Perez, February 1988

When the first issue of *Home Power* magazine came off the press in 1987, it was greeted by a renewable energy (RE) landscape that was very different than it is today.

In the 1980s, only a few regions in the United States had experienced RE installers. Most first-generation systems were designed and built by off-grid homeowners who were tired of living with kerosene lamps or engine generators, or often with no electricity at all. The idea of using RE equipment in home-scale applications was still revolutionary. Safety standards were in their infancy, and effective and durable system design approaches didn't have much of a track record.

As time went by, more and more systems were installed, but the RE community was fragmented. There was no Internet—many families living off grid didn't even have phone service. Renewable energy information exchange happened at a snail's pace—or by the mail's pace.

Off-gridders Richard and Karen Perez had been selling and installing RE systems in their region for awhile, and were well aware of the information void. They dreamed of creating an interactive meeting place that would bring together the growing community of solar, wind, and hydro users and facilitate an ongoing exchange of ideas to create better, safer, and more productive renewable energy systems and equipment. Their vision became *Home Power* magazine, launched in 1987. With the first issue distributed free to 7,700 readers, the clean energy community came out of the woodwork. Hundreds of eager subscribers signed up each week, and renewable energy immediately became a technology bridge to common ground for back-to-the-land hippies, sun-toughened ranchers, and assorted backwoods types of all persuasions.

The off-grid set of the '70s and '80s were energy pioneers who were willing to stick their necks out, and put both their time and money on the line to try out a new generation of energy systems. Their motivation was the promise of cleaner, quieter, and more cost-effective ways to generate electricity for rural properties that were beyond the reach of the utility lines.

Twenty years later, modern, grid-tied RE systems power everything from entire suburban subdivisions to downtown urban businesses. The early adopters of RE systems were fundamentally responsible for building the knowledge and experience base that helped pave the way for the flourishing renewable energy industry that is developing all over the globe.

Here's a look back—and a look forward—at just handful of the people, systems, homes, and hardware that filled the pages of *Home Power* in its early years. The history it holds is a glimpse at the foundation of a movement that continues to change the way the world makes and uses energy.

MICRO MOUNTAIN POWER

People: Harry & Marlene Rakfeldt; Lisa & David Buttrey
Issue: August/September 1988, *HP6*

Life throws a lot of changes our way. Sometimes homeowners move on, and their renewable energy system stays put. That was the case for off-gridders Harry and Marlene Rakfeldt.

Their rural adventure began when they bought remote property at 4,300 feet on the south side of Mount Ashland in southern Oregon in 1980. Although their land didn't have utility grid access, it had something better—two year-round creeks that dropped 300 feet down the steep and heavily forested mountainside.

In an interview for the August/September 1988 issue of *Home Power*, Harry pointed out that, "we like our creature comforts. We wanted our new home to be in all appearances the same as Dick and Jane's in the city." They tapped the renewable energy one of the creeks had to offer and installed a Harris hydro turbine, a bank of batteries, and a Heart Interface inverter. Once the hydro-electric system was up and spinning, the Rakfeldts settled into what they felt was a pretty normal life up on the mountain: "We can curl up in front of the VCR for a double feature," said Harry.

While Harry and Marlene moved on from their mountain home, its remote location coupled with an existing renewable energy system attracted nature lovers Lisa and David Buttrey. David is a professional photographer, videographer, and scuba diver; Lisa works with the Klamath Bird Observatory, helping to protect birds and their habitats. Lisa and David's professions are tied to the outdoors, and for them, living off-grid on a relatively remote, forested piece of land was a natural fit. They purchased the property in 1998.

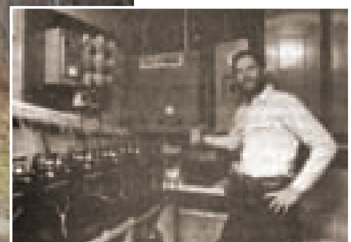
When they moved onto the mountain, some components of Harry's 13-year-old microhydro system were beginning to show wear and tear, and newer, more advanced equipment was on the market. Local RE systems installer Bob-O Schultze modernized the system with eight new batteries, a new Harris hydro turbine, and the latest in inverters at the time, a Trace SW4024. The new setup ran like a charm.

Nonetheless, the drought conditions that occurred during the early years of Lisa and David's tenure on the land meant relying on an engine generator through much of the late fall, when stream flows weren't sufficient to power the house. They again enlisted the help of their local "power guru." In 2001, Bob-O installed twelve Siemens 90-watt solar-electric (photovoltaic; PV) modules off the south side of the home's lofty deck, and the Buttreys have had sufficient energy ever since. Many homesites have good access to the sun for solar electricity generation, but in comparison, properties with a hydro resource tend to be few and far between. "Our situation is enviable, certainly," says Lisa.

Then: Marlene and Harry Rakfeldt on the deck of the original property, circa 1988. Inset: The original power conversion gear and battery bank.

Lisa and David's professions are closely tied to the natural world, and for them, living off-grid on a relatively remote, forested piece of land was a natural fit.

Now: Lisa and David Buttrey continue to enjoy and improve their mountain homestead.



Then (inset): Dave Palumbo with the original battery bank, circa 1990. Now: Dave next to the latest PV array.

"Looking back at our decision… to produce our own electricity for our new home site, I am amazed at how this one choice had such a profound effect on our lives."

NORTHERN ENERGY INDEPENDENCE

People: David & Mary Val Palumbo
Issue: June/July 1990, *HP17*

Many RE industry pioneers got involved professionally after first powering up their own homes with renewables, and experiencing firsthand the benefits of clean, site-generated energy. David Palumbo was one of these early trailblazers. His off-grid homestead grabbed the cover spot on *Home Power's* June/July 1990 issue.

Two houses and a combination horse barn/workshop were built on the 100-acre property, each with its own battery-based power system that was charged primarily with PV. A propane-fueled engine generator helped to keep the batteries charged up during Vermont's long and often sun-scarce winters. In 1987, a hydro system was installed and configured to charge the three separate power systems.

The original systems have remained largely intact. The first house they built on the property, now a rental, is still using a bank of 17-year-old nickel-cadmium batteries. The shop still gets some of its AC electricity from the original Heliotrope inverter, while a Studer sine wave inverter was added to power computers and sensitive electronics. More PV modules were added to each of the three systems over the years, along with a newer Harris permanent magnet hydro turbine. Combined, the site's current RE charging sources include 4.6 kilowatts (KW) of PV and a 400-watt (W) microhydro system. David says, "Over the average year, we receive 90 percent of our electricity from renewable sources (50 percent PV and 40 percent hydro) and the remaining 10 percent from the propane generator."

After successfully developing his family's off-grid property in the mid-1980s, David founded Independent Power & Light, a highly respected RE design and installation business in Hyde Park, Vermont. "When we decided to make our home in the beautiful Green Mountains of northern Vermont, we had no idea where this new adventure would take us," says David. "Looking back at our decision…to produce our own electricity for our new home site, I am amazed at how this one choice had such a profound effect on our lives."

EACH TIME'S A CHARM

People: Colin McCoy & Christine Reising
Issues: August/September 1991, *HP24*; June/July 2002, *HP89*

Anyone who has developed an off-grid property knows that it can quickly become the central focus of your life's efforts. Colin McCoy and Christine Reising know this firsthand—they've homesteaded from scratch not once, but three times, on different properties in southern Oregon. Colin went off grid in 1973, and refers to this period as BC—before Christine, who joined him and his daughter on the first property in 1976. All three of the homes they constructed were passive solar, earth-sheltered designs, built into south-facing hillsides—and each relied on renewable sources to provide all the homesteads' electricity.

Their current—and, word is, their last—home is located near Lake Creek, Oregon, with sweeping views of the valley below, and wide-open access for solar energy collection. The finished house is below grade on three sides, and the rubber membrane roof is earth-covered as well. The home's south face has ample windows to collect the winter sun, which warms the building's concrete floor and walls, creating even and comfortable temperatures. "We have to smile at our friends and relatives, who comment every time that they visit," says Colin. "The winter line: 'Your house is always so warm;' the summer line: 'Your house is always so cool.'"

Then: Colin and Christine in front of their earth-sheltered home, circa 1991.

Now: Colin and Christine take in the view from their current home's front steps.

"After visiting villages in Malawi, Africa, we appreciate all the more what we have, and realize that conserving resources is one of the ways that we can promote peace and harmony in the world."

Colin and Christine have long been conservation-minded and focused on using energy efficiently. Christine explains, "After visiting villages in Malawi, Africa, we appreciate all the more what we have, and realize that conserving resources is one of the ways that we can promote peace and harmony in the world."

Because they keep their electricity use in check, a modestly sized PV–wind hybrid system—600 W of PV and an 8-foot-diameter Bergey wind turbine—generate all the electricity they need. A separate, 12-volt system powered by a single Evergreen 120 W module energizes the home's original 12-volt lighting circuits. While this system may be considered small by today's standards, for years it has met all of Christine and Colin's electricity needs without any engine generator backup during the cloudy months. Colin comments that living without a generator really isn't that difficult. "You just have to develop the right habits."

Colin and Christine's sustainability efforts don't end with their passive solar home and RE system. They collect rainwater for all their domestic needs including a significant portion for irrigating their gardens. They grow the majority of their own food on site, right down to black and fava beans that they dry for winter eating. Limes, lemons, and tangerines grow in a sun-warmed greenhouse attached to the house. Colin sums up his and Christine's contentment with the homestead they've developed: "The older we get, the more we appreciate the way we live. It makes life easier."

SERIOUS ABOUT SELF-SUFFICIENCY

People: Sue Robishaw & Steve Schmeck
Issue: June/July 1993, *HP35*

In the 1970s, Sue Robishaw and Steve Schmeck quit their jobs in the city and joined the wave of back-to-the-landers who were searching for less complicated and more sustainable lifestyles.

They settled on Michigan's Upper Peninsula, where they literally dug in and built an underground home that relies, in part, on the soil's relatively constant temperature to buffer the area's long and frigid winters. The site did not have utility electricity, and Sue described their early off-grid electric scene: "As the old story goes, we started with a car battery and a car radio…with candles and oil lamps for light." Steve knew a thing or two about working on cars, which was what he needed to install the homestead's first solar-electric system—an old deep-cycle marine battery charged by two Arco 16-2000 PVs that powered a few 12-volt fluorescent lights.

Sue and Steve's homesteading efforts went far beyond their shelter and clean electricity efforts. A windmill mechanically pumps their water, a solar oven and a wood-burning cookstove help cook their meals, and a greywater system and composting toilet efficiently process and reclaim nutrients from what most folks think of as "waste." Extensive gardens provide the majority of their food.

When we recently checked in with Sue and Steve, we weren't surprised to hear that they were still happily planted on their homestead. The PV system has grown to just under 500 W, and all of the modules are vintage 1980s Arcos—a real-world example of the durability and longevity of PV technology. Sue says, "We're still enjoying life on our independently powered homestead in the North Woods, where we've lived now for almost thirty years. Our underground house, energy system, and lives are all

Then: Sue Robishaw and Steve Schmeck with their original Arco PV modules and solar oven, circa 1993.

integrated; we no longer think of it as an 'alternative' way of life—it's just a great way to live.

"[In the '70s] most of our friends talked; we moved. Many who moved went back, physically or philosophically. We couldn't imagine 'going back.' Why would we? We weren't trying to make a statement. It's just our way of life—a comfortable, happy, satisfying, and fun one."

"…We no longer think of it as an 'alternative' way of life—it's just a great way to live."

Now: Sue and Steve a decade and a half later. The PV array was expanded and moved to a sunnier location on the property, but the solar oven stayed put.

CALLED BY THE WIND

People: Shawn & Rebecca Otto
Issue: June/July 1995, *HP47*

In early 1994, Rebecca and Shawn Otto bought their dream property, and not too long after that, described it and the beginning of their renewable energy journey in our June/July 1995 issue:

> …[We found] our ideal parcel, 30 rolling, grassy acres abutting ponds and wetlands in May Township, Minnesota. We picked a spot with a good south-facing hill to berm into. We designed a superinsulated, passive solar-assisted home with an insulated slab, hydronic heating tied to a masonry wood heater, and superefficient appliances.
>
> Even before we began building, we would take long, slow walks out in the natural prairie grasses, wading through them, listening to them whisper and spit, and we began to notice that they were almost never still. The wind was almost always blowing. For people who think like we do, the next idea was a simple step in logic—wind power. We didn't realize what a huge leap we had just made, but our feet were already in mid-air, committed.

Shawn and Rebecca installed a 24-foot-diameter Jacobs wind generator on an 80-foot tower, after going through a great deal of local opposition to get approval. What began as a battle has become a success. Their home, named "Breezy," has become well known in Minnesota for its use of wind energy. Their neighbors, "who so vehemently opposed the wind generator at first, still live here, and now many of them say how they enjoy its beauty." Rebecca became Minnesota's state auditor last fall. Shawn is now a screenwriter (one of his recent projects was the film *House of Sand and Fog)*. They both use their public platforms to educate people about renewable energy.

Shawn comments on their RE system with the benefit of more than a decade of living with wind energy: "In retrospect, we wish we would have been even more aggressive in installing a taller tower and a larger system, since the current turbine produces only about 80 percent of our electricity. However, we are very glad to be living in a renewable energy house, and to be demystifying these ideas and teaching others. Every year or two, another person wanders up our driveway to ask wistful questions about whether 'those things' really work, and how to go about putting up their own wind generator, and we've helped some of them do just that."

Shawn and Rebecca's son (now 12) was born just after the wind-electric system was installed, underscoring their ethical decision to live their values. "We feel it was the most responsible choice we could make as parents—to do our part to conserve the world for his generation. This is our generation's calling."

The wind generator is now a fixture in the Minnesota neighborhood where the Ottos live.

Then: Friends and family celebrate Independence Day at Terry and Sue Ellen's renewably powered home. Inset: A microhydro turbine captures energy from a small stream that flows across the property.

Now: Terry Kinzel still enjoying life on the land in Michigan.

RE REALISTS

People: Terry Kinzel & Sue Ellen Kingsley
Issue: June/July 1995, *HP47*

Terry Kinzel and Sue Ellen Kingsley are practical people. Their no-nonsense approach to managing their small microhydro system has served them well, allowing them to wring as much energy as possible from the small stream that flows across their property.

In the summer of 1995, Terry and Sue Ellen shared their ten "rules" for living with a microhydro system in *Home Power's* June/July issue. Their lessons steered prospective microhydro users toward realism—in design, equipment selection and installation, maintenance, and system operation—no starry-eyed dreaming included.

They installed their system in 1991, tapping a stream that drops 16 feet with an average flow rate of about 75 gallons per minute. The energy in this falling water generates about 3 kilowatt-hours a day. Sixteen years later, their system is still operational and providing much of the electricity for their home on Michigan's Upper Peninsula.

> Sixteen years later, their microhydro system is still operational and providing much of the electricity for their home on Michigan's Upper Peninsula.

The system has seen some modifications over the years. An unexpected flood damaged the hydro control equipment, and Terry and Sue Ellen opted to upgrade to a new turbine that gives them half again the energy. They also replaced their modified square wave inverter with a grid-capable sine wave model, and reconnected to the grid so they can sell their surplus energy and reduce the size of their battery bank. Terry says, "Our energy income exceeds our use by a small amount, and with the 24/7 production of the hydro and the grid as backup, our original batteries have never been discharged below 95 percent of their capacity." Conservation and efficiency have allowed Terry and Sue Ellen to live comfortably with a modest amount of renewable energy.

Terry and Sue Ellen are continuing to look for ways to diminish their use of fossil fuels and live more sustainably. They have installed a "living machine" wastewater treatment system that is growing a profusion of bougainvilleas and calla lilies. And they are putting more effort into education these days. Their home, extensive gardens, and animals provide a setting for people to see an attractive life powered primarily by renewables.

OFF-GRID EVOLUTION

People: Risa Buck & Pam Lott
Issue: August/September 1995, *HP48*;
October/November 2005, *HP109*

Then: Risa and Pam's original off-grid home in Ashland, Oregon, circa 1995.

Risa Buck and Pam Lott were off-grid pioneers, but they don't live in the woods. Their small, energy efficient home is only blocks from downtown Ashland, Oregon. In 1995, Risa went through the approval process to build—without connecting it

Now: Pam, Risa and Ahlyo next to their rainwater collection pond.

to the utility grid. In the first of two *Home Power* articles about their home, Risa said, "I knew that there were many homes in southern Oregon that had incorporated solar power in varying degrees, but the City of Ashland had never officially granted occupancy to a home that chose not to hook up to the electrical grid."

> "…if I want to be current and continue being sustainable, I have to be willing to change."

If the utility grid is already present at a property, disconnecting from it is a romantic notion that is often not terribly practical, mainly because off-grid systems do not typically collect additional renewable energy once the batteries are full. In grid-tied systems, all available excess energy is routed to the utility grid, increasing the overall system production, often significantly. But when Risa made the decision twelve years ago to not hook up to the electrical grid, little provision in the laws existed for grid-intertied systems, and no tempting city, state, and federal incentives were available. Risa says that she "wanted to make the best choice at the time, and I believe I did, given what was possible."

Risa and Pam's plans for the property have been evolving. They recently added a 2.4 KW grid-tied solar-electric system to the rental house that shares the lot, helped along by generous local incentives. Pam says, "Now we are seriously considering a new concept—achieving a net-zero electric impact for the entire property. This half-acre of land holds three buildings—the front house, which is a rental and now grid-intertied; the straw bale studio; and our off-grid home. And we're looking into the feasibility of connecting our home PV system to the grid."

Risa sees advantages and drawbacks to hooking up to the grid. A batteryless grid-tie system would free them from the maintenance hassles and eventual replacement costs of the home's battery bank. But one downside to the new scheme would be losing the uninterruptible power a battery-based system provides. Being off grid has protected Risa and Pam from utility outages that have occurred at least twenty times during the last twelve years, leaving Risa a bit ambivalent about the possibility of going on-grid. "My feelings are mixed, but if I want to be current and continue being sustainable, I have to be willing to change."

STRAW & SOLAR

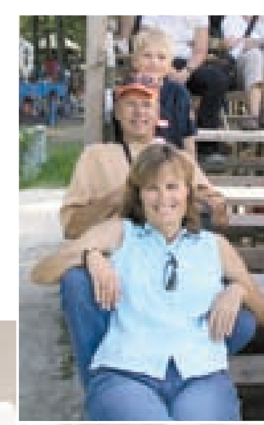
People: Jon & June Haeme
Issue: February/March 2001, *HP81*

Jon and June Haeme's straw bale home is modern, inviting, and renewably powered! The home was featured on the cover of *Home Power's* February/March 2001 issue, which included a photo essay with step-by-step images of the building's construction.

Jon and June have been living in their straw bale home for a dozen years, and are very comfortable in it. When they first built their home, many people expressed concerns that building with straw was not a good idea. They brought up common concerns about rodents, insects, mold, risk of fire, difficulties in obtaining insurance, and resale value. Fire testing on straw bale construction has shown that it exceeds ratings of standard drywall construction, and the stucco finish is so tight that the Haemes have never had problems with mice or insects. Obtaining homeowners' insurance has not been an issue for them, either. As to resale value, Jon and June have no plans to move, but they "have talked with a number of people who are interested in buying our home." Jon says that "after more than a decade living here, none of those fears have been justified."

Eight years ago, Jon installed a solar-electric system and a wind generator to reduce their reliance on the electric utility. Their 1 KW PV array and a micro-sized wind turbine energizes their lights, computers, TV, stereo, refrigerator, and freezer. Larger loads, such as the well pump and baseboard heaters, are run on utility electricity. Jon is working on plans

Now: June, Jon, and Jared Haeme. Then: The Haeme's straw bale home under construction in 1995.



to install a larger wind generator, which would offset the balance of the home's utility use. He has been installing systems for others for more than ten years, and became a NABCEP-certified PV installer three years ago.

"We put in a solar hot water system about three years ago, and haven't had to fill our propane tank since."

Electricity is just one aspect of this couple's renewable energy commitment. In fact, Jon feels that "the most cost-effective move we've made is heating water with the sun. We put in our solar hot water system about three years ago, and haven't had to fill our propane tank since."

An energy-efficient home powered with renewable energy demonstrates the Haemes' convictions. "Living with renewable energy is a passion for me," Jon says. "My experience of living with it every day has deepened my belief that we can live comfortably and reduce our use of fossil fuels at the same time."

RENEWABLE RETIREMENT

People: Don & Lois Laughlin

Issue: December/January 2003, *HP92*

Some people develop a "been there, done that" attitude as they grow older, abandoning their youthful idealism and vision along the way. Not Don Laughlin. After decades of renewable energy activism, he's still going strong.

In the mid-1990s, Don was part of a team that constructed a portable, solar-powered "bluesmobile" to provide electricity for nighttime entertainment during an annual bike ride across Iowa. Don also converted a Pontiac Fiero to an all-electric vehicle and was involved in a solar-electric installation at a local nature center, among other RE projects.

At home, Don put his money where his mouth was, installing a 21-foot-diameter wind generator in 2001. This wind-electric system provided a reliable source of electricity for the five years that he and his wife Lois lived in that home, offsetting about 80 percent of their electric bill.

"I have learned learned a lot over the years, and greatly increased my determination to do what I can to leave a model of sustainable technology for my kids and grandkids."

In recent years, not even retirement has slowed down this lively octogenarian nor dampened his enthusiasm for renewable energy. He and Lois recently decided to move into town, and sold their rural property and the wind-electric system. They didn't settle for a conventional home or a condo on the beach, but moved into a home designed and built to be a net-zero energy user.

Then: The original wind generator tower being installed, circa 2003. Now: Don and Lois in front of their new home.

Don and Lois's new home includes 350 square feet of solar hot water collectors that provide hot water for domestic use and for radiant-floor space heating. The house is superinsulated and well sealed against air infiltration, and was recently rated as a "Five-Star-Plus" Energy Star house. The Laughlins are looking forward to adding a solar-electric system soon.

Don admits that the up-front costs of investing in renewable energy can drive many people away, but says it is worth it in the long term. "I have learned a lot over the years, and greatly increased my determination to do what I can to leave a model of sustainable technology for my kids and grandkids."

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Old Letters

Passing the Torch (Feb 1988, *HP3*)

I somehow just received the second issue of your fine little magazine and I guess if anyone in the world can appreciate such a Brave Beginning, it's me (being the father of *Mother* [*Earth News* magazine], which started a lot of people in the same direction over 18 years ago).

Conversely, you folks (being about the best I've seen currently carrying Mother's banner onward) may well appreciate the enclosed small gift. It's a copy from the original print run of the very first Mother…

Perhaps you'll find Mother No. 1 worth keeping in your office as a symbol that the torch has been passed. Maybe you'll even swap me a copy of your first issue in exchange. And please do keep me on your mailing list and let me know if I can be of any help to you. I sure don't know it all, but I have been down the same path you're now traveling and I did learn a little.

John Shuttleworth,
founder of *Mother Earth News* magazine

Pillow Fights to PV (Dec/Jan 1989, *HP8*)

…In the winter of 1978–79, when our two oldest children were reading well on their own, we put wall-hanging kerosene lamps on each side of their room. From that moment, we lived in fear of the inevitable pillow fight burning down the home we had worked so hard to build. Thus began our affair with alternative energy!

Originally, we put RV lamps in the kids' room and a couple of lamps elsewhere in the house, powered off an old car battery that we charged every time we went to town...

Well, we've come a long way since then, and now have what we call the Simmons Rain or Shine System. Still being perfected, of course, as we can afford panels and such only one at a time. Starting with winter, the rain side of our system is a Harris wheel, powered by the runoff from a pond…Come the sun in the spring and our assorted PV panels take over, as the water table drops.

Visitors to our home rarely realize that we are not hooked into the power grid. Looks like any other house, with lights and plugs and all…

Dennis & Dottie Simmons (Simmons Natural Bodycare) • Bridgeville, California

Electronic Home Power (Jun/Jul 1990, *HP17*)

Each issue in the mail makes my face smile and my hands rush to tear open the envelope. Have you thought about using computer networks like EcoNet, PeaceNet, or the Whole Earth Electronic Library? I'd be curious to know how many of your readers might have access to a computer and a modem, along with the inclination to download articles via telephone. More and more folks are using telecommunications now. Moving electrons is the cheapest and most resource efficient way to transfer information. Seems a perfect match for *Home Power.*

Eric Heitz • Berkeley, California

Crude Defense (Dec/Jan 1991, *HP20*)

I'm going to Saudi Arabia as part of "Desert Shield." I predict that sooner than most Americans would wish, the

equipment and techniques described in your magazine will become more essential. Larger-scale previous use in the last seventeen years could well have prevented this très expensive military buildup. I think you are all the real patriots.

Name withheld

SolarMan Speaks (Dec/Jan 1991, *HP20*)

Stuart Ward was correct in issue #19 when he suggested one PV panel can be plenty. I run my entire home on three. My PV rack (built from Richard Perez's "How to Mount and Wire PV Modules" in *HP2*) is set up for four modules and I keep eyeing that empty spot, but I just don't need the power.

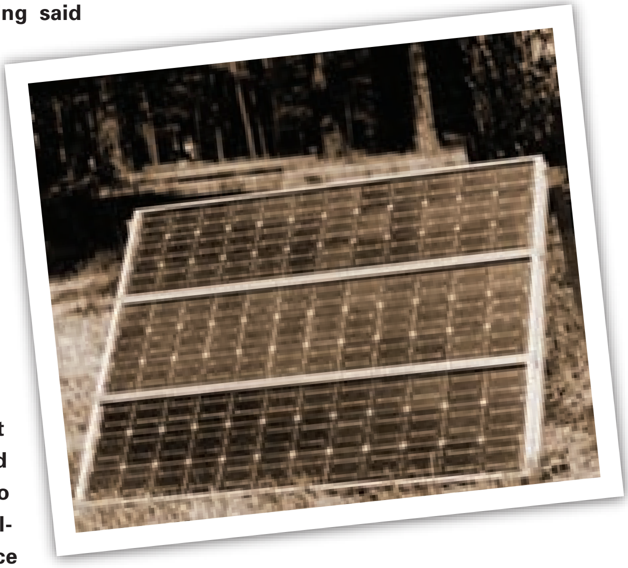
I would add to Stuart's point that solar is such a beautiful building-block concept. Start with one module and, if it's not quite enough, add another. As you purchase more electric devices, just add PV modules when you need them.

Phil Wilcox • Lower Lake, California

Step by Step (Oct/Nov 1991, *HP25*)

I'd really like to buy a few PV panels, but I'm not about to buy hundreds of dollars' worth of batteries and controllers. However, if someone made an inverter that could tie into the grid AND function independently...now that might be a worthwhile investment. The fellow at Trace Engineering said he'd asked about their making something like this, with an internal switch of some kind so one could dedicate the inverter to ON- or OFF-grid operation. Evidently the feeling is that it's not worth the money to develop. I have no idea as to their efficiencies and such, and I'm a dunce with electronics. However, I just don't see where it would cost all that much more to design and make a dual-function inverter. If Trace or PowerStar could build an interface inverter that matched the efficiencies of their current products and included proper safeguards so no linemen get bit repairing power lines, I think they could sell lots of them. Maybe I'm way off on this.

Bill Barmettler • Chehalis, Washington



power and economy. *Home Power* literally is "power to the people" from the only source that cannot be embargoed, rationed, or used to hold a nation hostage.

S. R. Staton • McKinney, Texas

Revolutionary (Dec/Jan 1994, *HP38*)

Home Power is almost certainly the ***Dr. Dobb's Journal*** of a coming revolution in home and small business design. Currently, the pioneers are literally forging the first trails; soon, the nation may be following these trails to a decentralized America of small-scale towns running on small-scale, renewable

Sun Birth (Oct/Nov 1994, *HP43*)

A brief note on our recent solar-powered home birth. Our daughter, Alice, was born the evening of June 29 at our home in South Hampton, New Hampshire. We'd had thunderstorms on and off all afternoon, and just after calling the midwife to say, "It's time to get over here," a neighbor I had called remarked that his power had been off for 30 minutes. Our PV/battery/inverter power setup and

solar hot water have been meeting our needs since the equinox and no one had been looking out of the windows, so we hadn't even noticed. Now when someone asks me, "How soon will the system pay for itself?" I can say, "It already has..."

James, Jocelyn & Alice Van Bokkelen • South Hampton, New Hampshire

Sending a Signal to the Utilities (Feb/Mar 2000, *HP75*)

I don't know if everyone is aware, but Trace Engineering has now made it possible for all solar guerrillas to unite and literally send a signal across the utility lines directly to the utilities that they are no longer in control of their grid!...

Here is how I propose a message be sent to the utilities over their own grid: First we need to equip all previously installed Trace SW inverter systems that are now using the grid for backup instead of "sell mode" with remote communications adapters and modems. Then announce via e-mail to the regulatory committees and the utilities that on a certain date all solar-powered systems across the country will be feeding the grid for the period of one week. We should give them about a week's notice, maybe two (to be nice). Then at the selected hour, we signal all SW inverters to switch to "sell" mode by reprogramming them remotely from a central location.

I hope we will have enough inverters, PV panels, and enough sun to create a big enough signal in the form of excess power on the grid that the utilities can't account for, that they will now longer be able to deny our existence! We can say, "Guerrilla solar was here."

David M. Austin • via e-mail

California Buydown Inspiration (June/July 2001, *HP83*)

I downloaded and read your article concerning the California RE buydown program (*HP82*, pg. 48).

Several weeks ago, a co-worker showed his home experiment to me. He had connected a couple of PV panels to his PC to see if he could run it with the sun's energy. "Holy cow!" I thought, as I realized that here was a way to save money and help the environment.

After a little research (okay, a *lot* of research...), I signed a

contract on Saturday, April 14, 2001, with Carlson Solar in Hemet, California, to install a solar-electric system rated at 10 KW at my house in Palm Springs. I refinanced the house to pay for the system, which will be installed the first week of June 2001…

Your article was the first I've seen in the magazine that actually had anything good to say about what's happening here in California. I hope more people take the lead.

Jim Haggerty • Yamaha Motor Corp.

The Next Generation of Solar Bozos (Jun/Jul 2003, *HP95*)

It was just over two years ago when I constructed a micro-sized solar and wind energy system that has successfully and reliably provided basement lighting in our home (see *HP82*, pg. 32)…

As we prepare to relocate to a new home, the planning has begun for establishing a more permanent solution. And with this comes a surprise—a young volunteer who has asked to help install the new system when it is time…Four years old now, she does not remember a time in her life without a solar panel, a wind generator, and battery care.

For me, making the step into renewable energy has taken a lot of careful thought and consideration. For her, she doesn't understand why the neighbors don't have a solar panel…

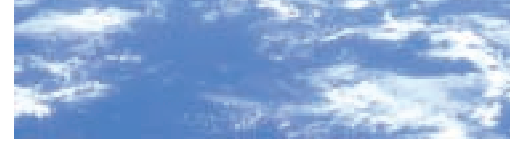
Call me naïve, but only now have I realized that we have the responsibility to share our enthusiasm beyond just the comfortable circles. While it may prove difficult to overcome many of the barriers facing renewable energy today, we all know what seeds do over time.

Mike Lew • via e-mail

Phantom Loads (Jun/Jul 2006, *HP113*)

Surprise, surprise, *The Economist* just ran an article on phantom loads! It was in the March 11–17 issue, "Pulling the Plug on Standby Power." They did a decent job on the subject and I was very pleased to see it, though I must say they are a bit behind the curve…Thanks to the *Home Power* crew for bringing this to the attention of the world more than a decade earlier.

Jim Palmer • Courtenay, BC, Canada



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Getting Started with Renewable Energy

PROFESSIONAL LOAD ANALYSIS & SITE SURVEY

Ian Woofenden with Chris LaForge

Are you thinking about having a renewable energy (RE) system installed at your home or business? Perhaps you're wondering how to approach the project, and how best to get started. Whether you're new to renewables and need a helping hand or an RE enthusiast who wants some straightforward advice, an RE professional can provide valuable insight and expertise. This article will help you understand the process of working with a pro, so you can be an educated consumer—and get the system you've always wanted!

Load Analysis

The first step in renewable energy system planning is to determine how much energy you want or need to make. A key question is whether you will be off grid or on grid.

Off-grid electrical systems are installed in locations where the cost of bringing in utility power is prohibitive. These stand-alone systems must provide all the site's required electricity, either with renewable energy sources or a backup engine generator. Energy efficiency and conservation become critical, and the viability of the system can hinge on your ability to make the most out of a kilowatt-hour (KWH). For this reason, most RE consultants will ask you for a detailed load profile of your current or projected use. They'll want to know each electrical appliance you use or intend to use, what it draws in watts, and how many hours per day you will use it.

Off-grid system design must also take into account seasonal energy availability and use. For example, you may require more energy in the summer because your home is for vacation use or you pump a lot of water for irrigation. In a year-round home, the critical energy time may be winter, when more lights and other loads are typically used. If your main resource is sunshine, you may size the system based on the availability of winter sun at your location, since that's when you'll have a critical need. Wind and hydro resources will lead your design in other directions. The question in the end may be "how often do I want to run a backup generator?"

On-grid electrical systems require a different approach, in more ways than one. First of all, there is no pressing need to accommodate the complete load. Systems can be designed to cover 10, 50, or 100 percent of your home's electrical use, or anywhere in between. The utility will pick up any balance, supplying whatever is demanded by the users and their electrical loads. Also, if your state or utility has an annualized net metering program, *when* you have renewable resources is not as important. During the sunny summer months, your grid-tied RE system can produce surplus

Top left: Courtesy www.windenergy.com

solar energy, offsetting all your energy use and building up KWH credits that you can use in the cloudy months, when the system's output is lower.

It is still good to know what your home's loads are so you can replace inefficient appliances with more efficient ones, but compared to off-grid systems, it's much easier to determine your electricity use. Just look at recent utility bills and find the average KWH used per day. Using this figure, a system can be designed that will offset all of your energy use. Or if the budget doesn't allow it, your dealer can give you a realistic expectation of what percentage of your energy use a specific system will cover. Ideally, a detailed load analysis should be done for *all homes*, so the owners understand how and where they are using energy, and can learn how to use it more efficiently.

Site Survey

Once your energy requirement is quantified, many dealers start by talking about cost, even before looking at a site. They will roughly calculate what size of system you might need, and then give you a ballpark cost figure. This reality check will help you understand how much an RE system will cost and what it will do for you. Don't let this no-nonsense approach put you off. It means you've found someone who wants you to be satisfied, not disappointed, with the system.

If you decide to move forward with your potential RE project, your installing dealer or renewable energy consultant will schedule a site visit to assess what RE resources are available on your property. This site survey may cost from $100 to $300 plus travel, but it can save you from poor choices and wasting thousands of dollars later on. A good survey leads to a good system in the same way that a tailor custom fits a suit to your build. Skilled design makes all the difference in system performance.

Although you might come to the table with preconceptions about what you want to do, be open to looking at all options. Often a potential customer is focused on wind, when solar energy makes more sense for their site, or a stream cascading down through their woodlot can provide the most cost-effective energy.

Savvy consultants talk not just about electricity, but about how folks want to heat the home, pump and heat their water, dry clothes, cook, operate their shops—you name it. They should always stress the primary untapped resource—efficiency. When you price a system for an inefficient load profile and compare it to the cost of upgrading appliances and the smaller RE system that will result, you'll quickly see how conservation and efficiency save you money.

Getting your whole family, or at least you and your spouse, involved in the site survey and energy analysis process is ideal. Especially with off-grid systems, all the people who will be using the system need to know as much as possible about how it was planned, how it works, and what they can do to make it run well.

These questions and more may be asked of you:

- Why are you interested in renewable energy? (Motivation is a significant issue in system design—"why" is often more important than "what" or "how.")
- What resources do you want to use?
- How do you plan to use the site (full-time residence, vacation cabin, etc.)?
- Who else will be using the system? How many people?
- What is your conservation/convenience quotient? How flexible are you and the others who will use the system?
- Do you want to conserve and minimize your consumption, or do you want your power on demand without worrying about how much energy you're making?
- Do you want the system to grow over time, or should it be full-blown at the beginning?
- What is your timeline?
- What is your desired budget?

Solar Energy

The site surveyor will evaluate your property with a solar site selector tool. This equipment helps determine in which locations your property or roof are shade free, and during what times of year. This will identify the best location for your solar-electric array or solar hot water collectors. Several sites on your property can be assessed for their potential production.

Sample Electrical Loads Worksheet

		Summer Months			Winter Months		
Item	Watts (W)	Avg. Hrs. / Day	Avg. Days / Wk.	Avg. WH / Day	Avg. Hrs. / Day	Avg. Days / Wk.	Avg. WH / Day
Evaporative cooler	400	8.0	7	3,200	0.0	0	0
Fridge, 18.5 c.f.	510	4.0	7	2,040	3.6	7	1,836
Well pump, 1 hp	1,600	1.0	7	1,600	0.9	7	1,440
Computer & peripherals	190	3.0	7	570	3.0	7	570
Microwave oven	1,500	0.2	7	300	0.2	7	300
TV & home entertainment center	75	4.0	7	300	5.0	7	375
Lighting (4 CFLs, 25 W ea.)	100	2.5	7	250	4.0	7	400
Answering machines, clocks, etc.	8	24.0	7	192	24.0	7	192
Clothes washer	350	1.0	3	150	1.0	3	150
Clothes dryer (gas)	350	1.0	3	150	1.0	3	150
Furnace blower	350	0.0	0	0	6.0	7	2,100
			Total Watt-Hours Per Day	8,752			7,513

Photovoltaic (PV) modules are expensive, so it's best to optimize their production. This means a minimum of full sun from 10:30 AM to 2:30 PM, and preferably more. Solar hot water collectors are somewhat more forgiving as far as partial sunlight from shading and poor angles. But the fuel for both technologies is sunshine, so it's critical to find the best locations for the equipment.

If necessary, PV arrays can be sited a few hundred feet or more from the home to find a good site. Because modern arrays often run at high voltage, smaller-gauge (and less expensive) wire can be used to transmit the energy. Solar hot water systems need to be much closer to their point of use. Running pipes more than 100 feet becomes costly and incurs high heat losses.

Solar hot water systems are usually sized to provide enough hot water for a household each day the sun shines. Instead of having a recovery time of an hour or a few hours like tank-style gas or electric water heaters, a solar water heater has a recovery time based on the daily sun cycle. Keep in mind that solar hot water systems usually depend on a backup water heater for days of no sunshine or times of heavier use like when your holiday guests greedily drain all your stored solar hot water.

In the United States, typical hot water use ranges from 10 to 30 gallons per day, per person. Fifteen gallons of hot water per day per person is reasonable if you use basic conservation measures, making a solar hot water system a cost-effective solution with a quick payback. Keep in mind that all solar thermal systems can produce about twice as much heat in the summer as they do in the winter. Although this isn't normally a problem in the United States with small systems, this seasonal load imbalance should be considered for larger systems—in particular solar space heating systems.

Your dealer may ask you questions like these:

- Where would you prefer to locate your solar-electric array and solar collectors?
- What are your aesthetic issues?
- Do you prefer the look of roof mounts, pole mounts, or ground mounts?
- Where do you want the balance of system (BOS) components located?
- Where is your electrical service panel and meter?
- Where is your existing water heater?

Wind Energy

If you have a potential wind energy site, your consultant should be asking if you are a hands-on person—or at least "eyes on." With no moving parts, PV systems lend themselves to near maintenance-free operation. Wind turbines have moving parts, which means wear and tear, regular maintenance, and possible failure and repair. Neglecting to maintain equipment properly will not only decrease system life, but poorly cared for components can also become hazards.

A wind site survey includes looking for the obvious indications of wind potential, such as tree branch deformities due to wind (called "flagging"), documented average wind speeds, and anecdotal evidence from local old-timers. Your surveyor will hunt for possible tower sites, and observe obstructions within 300 feet of them. She or he will determine if adequate room exists for a tilt-up tower, or if a guyed lattice or freestanding tower is necessary. Freestanding towers have the smallest footprint, and may be the only appropriate tower if you live on a small lot. Guyed lattice and tilt-up towers require lots of space for guy wires, or for raising and lowering the tower for turbine maintenance.

Your dealer may ask at least the following wind-specific questions:

- Why do you want a wind energy system?
- Will you really perform the required maintenance or hire a technician to do it?
- Are you willing to participate in the ongoing "research and development" of wind-electric systems? These systems can and do fail, and owners need to expect this. If you are not one to roll with the punches, you need to consider other systems with fewer potential problems.

Microhydro-Electric Energy

Microhydro-electric systems can be some of the most cost-effective systems available, though they are sometimes difficult to implement. Local, state, and federal authorities all can have jurisdiction over your activities. Unless you have complete ownership of the water resource, you often end up right at the authorities' door. That said, the constant charging output from the careful use of microhydro is ideal. It also works well paired with a solar- or wind-electric system, since good creek flows often come at times when sunlight is limited and winds are slow.

When considering a microhydro-electric system, your dealer may ask you these questions:

- Do you own the resource?
- What is the available head (vertical drop from collection point to the turbine site)?
- What is the rough flow rate available (in gallons per minute)?
- What is the distance between the low end of your stream and your home?
- Is the resource year-round or seasonal?
- What authorities have jurisdiction over the stream?
- Is it a fish stream?
- Are any stream-reliant species present, or does the potential exist?

Hybrid Systems

Most off-grid RE systems are hybrids in the broad sense of using more than one energy resource. Often, engine generators provide backup energy for extended cloudy or windless periods. But PV–wind hybrid systems can be ideal if the client fits the wind system profile. They work exceptionally well in many areas because it is often windy when it's not sunny, and vice versa. The same goes for solar–hydro hybrid systems, with water typically flowing at higher rates in the winter, when it's less sunny. These systems can reduce the use of nonrenewable sources substantially—or even completely. This fact makes hybrid

systems very attractive to people who want to minimize the use of nonrenewable energy sources.

Hybrid capability is less important with grid-tied systems, which use the utility grid as a backup. Batteryless grid-tied systems are often the most cost-effective, environmentally friendly, and easy to operate systems available.

Good Analysis Pays Off

A professional load analysis will help you understand where your energy is used and how to reduce it. A site survey will assess what your property has to offer, and may even reveal resources that you may not have recognized.

Together, these two steps should lead to a well-designed RE system that fits your circumstances and needs. They should also result in a smooth installation and help you avoid unnecessary expenses. Don't overlook these critical steps on your road to using renewable energy in your home!

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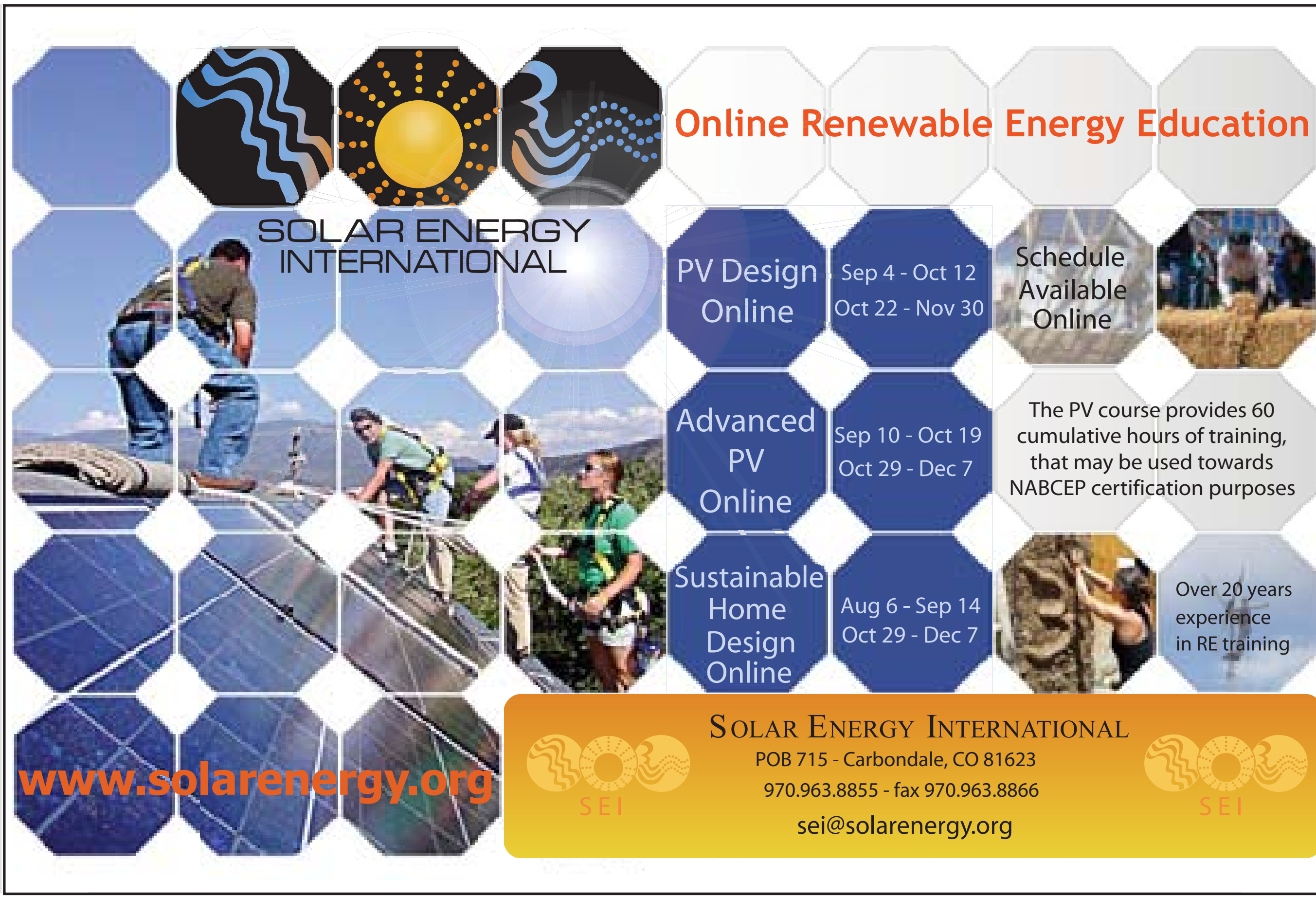

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SOLAR ELECTRICITY SHINES IN MILWAUKEE

by Curt Blank

Unlike a lot of solar enthusiasts, Curt Blank's concerns were not environmental when he first considered having a solar-electric system installed at his home in Milwaukee, Wisconsin. His primary motivation? Dollars and cents, plain and simple.

In the summer of 2005, I was channel-surfing and landed on an HGTV program called "I Want That." The particular episode was showcasing a solar-electric (photovoltaic; PV) system. As a self-proclaimed techhead—my house is full of computers, I write code and push local weather data up to the Web—I always have an eye out for cutting-edge electronics. The thought of having a roof covered with electricity-producing silicon made me put down the remote. I decided on the spot to do some more research and give PV technology a closer look.

Delving into the Details

Real-world data has shown that solar-electric modules will typically produce energy for 25 years and then some. Practically speaking, investing money in a system now is the same as buying your electricity decades in advance. The clincher is, as utility rates rise, the cost of the electricity I generate using solar energy will be locked in for a *minimum* of ten years under my current arrangement with the utility. This is a good idea if you live in a state where electric rates are on the rise—and that's pretty much all of them. Average Wisconsin residential electric rates have increased 24 percent, just in the past six years! Besides insuring myself against rate hikes, I'm protecting my financial future. Even though it's still on the horizon, retirement is eventually headed my way. Fixing my cost for electricity will be a handy feature, since my income will one day be "fixed" too.

During my initial Web research, I discovered that my local utility, We Energies, offered financial incentives for residential PV systems through Wisconsin's Focus on Energy program. On top of that, I was hearing rumblings that a new federal solar tax credit was going to become available in 2006. I'd assumed that a PV system would be expensive, and up-front they are. But the possibility of using incentives to offset the initial cost really caught my attention, and was the motivation I needed.

To receive the maximum amount from the Focus on Energy incentive program, my system installer had to be certified by the North American Board of Certified Energy Practitioners (NABCEP), a nationwide organization that tests and certifies solar installers. I started to shop around for electrical contractors with PV system installation experience and NABCEP certification, but I came up empty handed—none were available locally. So I expanded my search and located Andrew Bangert, from H&H Solar Energy Services in Madison. He made the 90-mile trip to Milwaukee to evaluate my site, and put a bid together.

Getting the Site Right

Once his boots were on the ground, or actually up on the roof, Andrew quickly determined that the four 40-foot-tall pine trees, to the south and southwest of the house, would need to come down. Another complicating factor was the dormer that was smack in the middle of my south-facing roof. Without it, I would have had about 600 square feet of clear, south-facing roof. But the dormer reduced the available space to two roof surfaces of about 200 square feet each. With this constraint, Andy's initial inspection indicated that about 3,300 watts was the best I could do with the 187-watt Kyocera modules I had specified—without hanging panels left, right, and upside down.

The remaining task before we could install the system was to reshingle the roof, although this was strictly by my choice. The existing composition roofing still had about five years of life left before it would need replacing, but it didn't make sense to me to install the array, which I didn't plan on moving for 25 years or more, only to remove and reinstall it a handful of years later. The roofing added an additional $4,500 to the bottom line, although it's an expense I would have eventually faced, regardless.

Household Electrical Loads & Efficiency

One of the first steps in any home-scale solar-electric project is doing what you can to make your household as energy efficient as possible. Every watt-hour you save is one that your PV system doesn't have to generate, leading to a less expensive system. All the lightbulbs in my house are energy-saving compact fluorescents, and it's been that way for fifteen years or so. Over the past five years, I've upgraded all my major appliances with the most energy efficient ones I could buy. I even undertook the expensive project of replacing the old single-paned windows in my house with tight, well-insulated double-paned units a few years back.

Even with these measures in place, I still use a lot of electricity—about 1,400 kilowatt-hours per month, on average, which sets me back between $100 and $160. While I do my best to conserve energy, I have three computer servers, and three DirecTV receivers with TiVo running 24 hours a day. This equipment uses a lot of electricity day in and day out, and accounts for the majority of my electricity use. But for the time being, it allows me to work from home for my employment with the Information and Media Technology Department at University of Wisconsin at Milwaukee, and for my own personal Web and programming work. I also enjoy woodworking as a hobby, and the 2 to 3 hp electric motors in my shop guzzle electrons whenever the woodchips are flying.

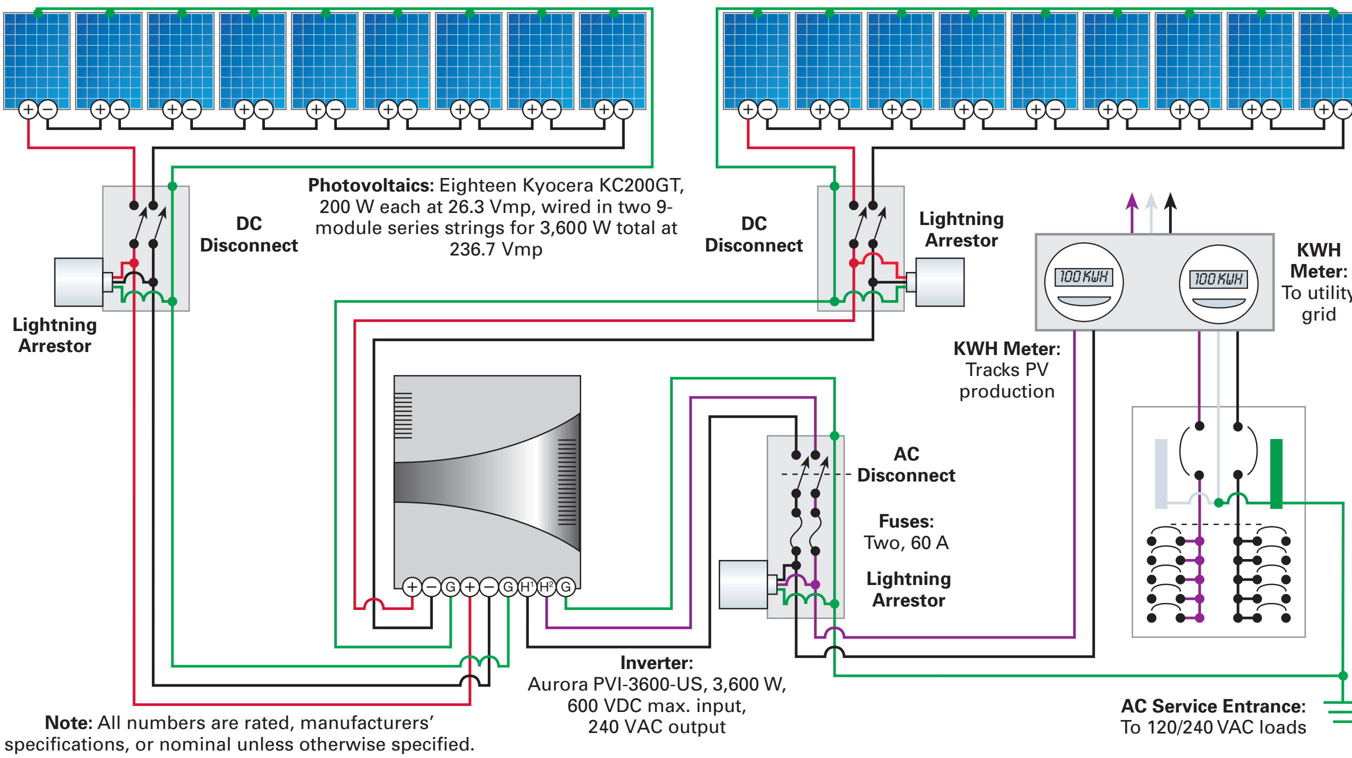
Sizing Up the System

After surveying the site for solar access and shading, and getting a handle on my electrical use, Andrew put together a bid for a PV system that was within my budget, and would offset about one-third of my present electricity use. His quote of $21,500 (before incentives) was higher than I'd anticipated, but it wasn't out of the ballpark. Even so, I ended up hemming and hawing for several months over the initial cash outlay before I signed the contract in December 2005. We tentatively scheduled installation for the coming spring.

A little delay was a good thing: That spring, Kyocera increased the output of the modules we selected from 187 watts to 190 watts each, raising my array's total DC output to 3,420 watts. But the modules were in short supply at that time because of a silicon shortage, which has since eased. As a result, Andrew pushed the installation date into midsummer. And again, our patience was rewarded—before my modules shipped, Kyocera upped the module output to 200 watts each, increasing the array output to 3,600 watts. Who says procrastination's a bad thing?

Top: The roof is reshingled in preparation for the PV installation. Bottom: Andrew Bangert and Chad Silverthorn of H&H Solar Energy Services begin assembling the PV arrays.

Blank Grid-Tied PV System



Ready, Set, Install

In June, the trees came down and the PV system went up. Andrew and his associate Chad Silverthorn made quick work of the installation, and I'd recommend them to anyone looking for pro solar installers in southern Wisconsin. A 1,800-watt array was mounted on each side of the dormer and separate wiring from each array was run in conduit down to the inverter. One of the nice features of the Aurora inverter that was specified for the system is that it can independently track and optimize the power outputs of two separate series

L to R: The solar array's AC disconnect, PV production meter, and utility meter.

Tech Specs

Overview

System type: Batteryless, grid-tie solar-electric

Location: Milwaukee, Wisconsin

Solar resource: 4.5 average daily peak sun-hours

Production: 358 AC KWH per month (first 11 months of operation)

Utility electricity offset: 29 percent

Photovoltaics

Modules: 18 Kyocera KC200GT, 200 W STC, 26.3 Vmp

Array: Two 9-module series strings, 3,600 W STC total, 236.7 Vmp

Array installation: UniRac mounts installed on south-facing roof, 40-degree tilt

Balance of System

Inverter: Power-One (formerly Magnetek) Aurora PVI-3600-US, 600 VDC maximum input voltage, 90–530 VDC MPPT voltage window, 240 VAC output

System performance metering: PC-based inverter monitoring with custom code for Linux operating system

PV System Costs

Item	Cost
18 Kyocera KC200GT PV modules, 200 W	$16,027
Aurora PVI-3600-US inverter, 3.6 KW	2,187
Labor	1,856
Miscellaneous electrical	1,023
UniRac PV mounts	900
Tax	825
Shipping	60
Total*	$22,878
Focus on Energy rebate	-$8,007
Federal tax credit	-2,000
Grand Total	$12,871

*Total cost slightly higher than initial quote due to additional equipment installed to participate in We Energies buy-back program

strings of PV modules. In my case, this was a worthy feature, since trees to the east and west of the house, along with the dormer and chimney, cast some shadows on one array or the other in the early morning or late in the afternoon when the sun is low on the horizon.

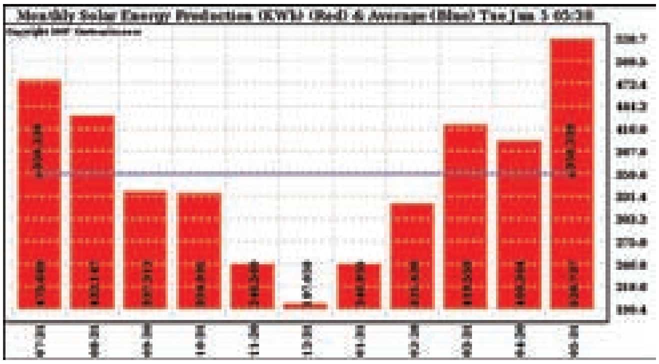
The inverter will also function down to 90 VDC. So except during extremely hot summer conditions, when the modules' operating voltage is low, I can essentially lose the output of five of the nine modules in a string to shading and the Aurora will still produce energy. Since these shading conditions only exist at the beginning and end of each day, this low operating voltage capability doesn't add all that much additional energy to my system's total production. But I figured that it made sense to optimize my PV system's performance in every way possible, which would also optimize my financial investment.

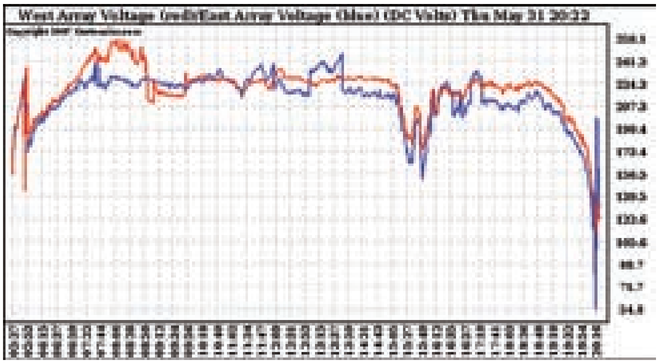
We had to delay the final commissioning of the system for two weeks, so that our local utility could inspect the system prior to bringing it online. This delay was the only one that did me no good; after more than a year of anticipation, two weeks of perfectly good summer sunshine wasted on inoperative PVs was almost too much to handle! But on June 27, the system came online, and the modules and inverter went to work making electricity from sunshine.

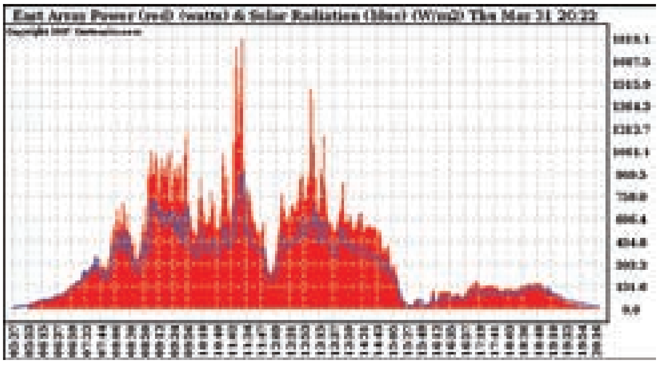
System Monitoring & Performance

My techhead tendencies drove me to create a seamless way to monitor the PV array and inverter output, and automatically display the data on the Web. Being a Unix System Administrator and a heavy Linux user, I was not overjoyed to hear that the Aurora inverter came with software that only ran on Windows operating systems. But with some help from the inverter manufacturer, I was able to sort through the inverter's communications protocol and write the necessary code that enabled monitoring via my Linux-based computer network. I've been collecting performance data since the system came online, which is available for viewing on my Web site (see Access). If you're a Linux/Unix user, you can download my Aurora communications program as well.

One thing I immediately noticed after reviewing some of the early system output data was that the modules were often operating below their rated output during the summer. After talking with Andrew from H&H, and the folks at Magnetek (Power-One has since purchased the Aurora line of inverters), I learned that the higher the ambient temperature is, the lower the voltage produced by the PV modules will be. Despite long, sunshine-filled summertime days, the array experiences a higher peak array output during the shorter, colder days of late fall, winter, and early spring. My best single generation day to date was April 5, when the system cranked out 24 AC KWH. But the bottom line is that cumulative energy is what I'm after. While peak power or the energy produced on a given day is often higher during the colder months, the long days and mostly clear weather during the summer is when the system generates the most energy.







Datalogging snapshots of the PV system's production.

A little bit of programming magic lets Curt keep tabs on his PV array and inverter output via the Web.

The Big Payback

So far, my PV system has produced more than 4 megawatt-hours of electricity, and knocked close to $900 off my electric bills. Originally, I'd predicted a ten- to twelve-year financial payback for my PV investment. After living with the system for awhile, it looks like I may end up on the high side of my original estimate. But even if it does take twelve years for the system to offset its original cost, my modules are warranted to generate electricity for another thirteen years, and will likely continue to do so for fifteen or more years beyond that. After the twelve-year mark, it's all *free* electricity. And that'll be right around the time I'll be thinking about retirement. Perfect.

Access

Curt Blank • Curt.Blank@curtronics.com • www.curtronics.com/solar

Andrew Bangert or Chris Collins, H&H Solar Energy Services Inc. • 2801 Syene Rd., Madison, WI 53713 • 608-273-3434 • info@hhsolarenergy.com • www.hhsolarenergy.com • Installer

Focus on Energy • 800-762-7077 • www.focusonenergy.com • Wisconsin RE & efficiency incentives

PV System Components:

Kyocera • www.kyocerasolar.com • PV modules

Power-One • 805-987-8741 • www.power-one.com • Aurora (formerly Magnetek) inverter

UniRac • 505-242-6411 • www.unirac.com • PV mounts

The Half Plan

by Gary Reysa

Reducing Your Carbon Footprint, Part Three: Defeating Drafts & Improving Insulation

Investing in energy-saving projects to reduce greenhouse gas emissions is a win-win situation—you can do something that is good for the planet and also earn a good economic return. Tap into these tips to make your home more comfortable, cut your utility bills, and decrease your household's carbon dioxide (CO_2) emissions.

An inadequately insulated and sealed home is especially vulnerable to both summer heat and frigid winter temperatures—*and* high cooling and heating bills. If your energy bills are going through the roof, your home's heat (or air conditioning) might be escaping there too—as well as through your walls, ceilings, floors, and ductwork.

Besides taking a big bite out of your budget, home heating and cooling can contribute considerably to greenhouse gas emissions. More than half of all U.S. homes use natural gas for space heating, and about 30 percent heat with electricity, which is generally provided by coal- or natural-gas-fired power plants. The result? According to the energy policy group Rocky Mountain Institute, thousands of pounds of CO_2 are released annually per household. (See the CO_2 emissions table for details on how your home energy use contributes to climate change.)

According to the U.S. Department of Energy (DOE), investing just a few hundred dollars in good insulation and home weatherization strategies can reduce your heating and cooling needs by up to 30 percent. Last year, my wife Joan and I took on the challenge of cutting our energy consumption—and related CO_2 emissions—by 50 percent. The five projects detailed here (out of the twenty we implemented) cut our bills by more than $500 each year—recouping the materials costs in the first year and preventing more than 1 ton of CO_2 from being released annually. (For tips on prioritizing your own CO_2 reduction plan, see the Footprint sidebar.)

Direct CO_2 Emissions by Source

Fuel Type	Output Rate (Lbs./KWH)
Coal-generated electricity	2.03
Petroleum-generated electricity	1.91
Natural-gas generated electricity	1.15
Coal	0.70
Heating oil	0.60
Propane	0.51
Natural gas (pipeline)	0.42
Hydro-generated electricity	0.04
Nuclear-power generated electricity	0.00
Fuelwood (if sustainably harvested)	0.00
Solar-electric/wind-electric	0.00

Source: Energy Information Administration/BP

*Table does not account for CO_2 produced during plant construction or decommissioning, equipment manufacturing, mining, or fuel processing.

Reduce Your Carbon Footprint

Reducing your energy use can pay off—both economically and environmentally. Follow these four easy steps to start saving.

1. Conduct a home energy audit and make a list of potential projects to reduce your household energy use. Many utilities will send out a technician, often for free, to assess your home's efficiency and provide a report and recommendations for efficiency upgrades. If you're off the grid, or your utility doesn't offer audits, you can hire a pro to perform an energy audit or do it yourself, using the online Home Energy Saver program (see Access).

2. Estimate the cost, energy savings, time and degree of difficulty, and greenhouse gas reduction for each project. For this article's projects, financial savings in fuel in the first year are based on the projected kilowatt-hours (KWH) saved, and multiplied by $0.079 per KWH—equivalent to my cost for propane, which we use to heat our home. The projected 10-year fuel savings assumes a 10 percent rise in fuel prices each year. Converting all nonelectrical forms of the energy to KWH will allow you to compare energy savings for electricity, transportation, and heating projects on the same basis. To estimate greenhouse gas savings for each project, I used the calculator at www.infinitepower.org.

Some handy conversion factors:

1 KWH = 3,412 Btu

1 gal. of propane = 92,000 Btu or 27 KWH

1 therm of natural gas = 100,000 Btu or 29.3 KWH

1 gal. of gasoline = 125,000 Btu or 36.6 KWH

1 gal. of heating oil = 139,000 Btu or 40.7 KWH

3. Prioritize projects according to CO_2 savings, and time, budget, and skill constraints.

4. Keep a file of your utility bills to review, so you can see what progress you are making. The bills also can be used to demonstrate your home's improved energy efficiency if you plan to sell it, and may be needed to claim rebates or tax credits.

The combined result of 100 million American families, each targeting a 20-ton reduction in CO_2 emissions, would reduce total U.S. CO_2 emissions by about 25 percent.

Dodging Drafts

A home's air leaks are often felt as drafts during cold weather, but infiltration can happen any time of year. Drafts around windows and doors are typically mistaken as a home's biggest energy drains, and homeowners are more prone to attack ones they can feel first. But in many homes, the most critical air leaks occur through the attic and basement.

In attics, leakage is likely to be greatest where walls meet the attic floor. Dirty insulation can give you clues for areas to seal, since it indicates that air is moving through. Seal the big "holes" first by stuffing garbage bags with loose-fill insulation that you can size to fit the spaces or, in less challenging situations, use a section of reflective foil or rigid foam insulation. Address smaller leaks with spray-foam insulation or caulk. Stuffing fiberglass insulation in openings is not effective, as it impedes airflow very little. Special techniques and materials should be used for sealing around furnace flues or other pipes that may become hot.

Air leakage in basements is most common where the concrete or block foundation wall comes in contact with wood framing. For optimal energy savings, fill gaps or cracks between the sill plate and foundation, at the bottom and top of rim joists, and around any penetrations. Use silicone or acrylic latex caulk to seal gaps or cracks less than 1/4 inch and expanding spray foam for gaps between 1/4 inch and 3 inches. In new construction, rolls of foam sill-seal should always be used between the foundation and the mud sill to eliminate air infiltration.

I addressed both the attic and basement in my home, and weather-stripped around windows and doors. And although the savings for this project are difficult to estimate, the low up-front cost of the project and its results are worth any time and money spent. Preventing air infiltration and improving a home's insulation offers a terrific payoff in a home's energy performance—one that you will definitely see reflected in your reduced heating and cooling bills. (For details on calculating energy savings, see Access.)

Project 1: Sealing Gaps & Cracks

Up-front Cost: $50

DIY Labor: 8 hrs.

DIY Difficulty: 4 (on a scale of 10)

Annual Energy Savings: 1,980 KWH

First-Year Energy Cost Savings: $156

Projected 10-Year Savings: $2,493

Annual CO_2 Reduction: 1,009 lbs.*

*Based on reduction of propane used for home heating; 0.51 lbs. CO_2 released per KWH equivalent.

Improving Insulation Overhead...

The DOE provides minimum R-value recommendations for homes based on climate, heating source, and the type of space needing insulation (attics, basements, or walls). Definitely consider exceeding these levels—known as "superinsulating"—for maximum energy efficiency. (For DOE recommendations, see Access.)

If you have a limited budget, experts recommend adding insulation in areas, such as attics, where it can be done most easily—and usually, least expensively. The existing insulation in my 12-year-old home's attic was about 10 inches of loose-fill fiberglass, which provides about R–2.2 per inch, for a total of R–22. For our climate here in Bozeman, Montana, the DOE recommends attic R-values of 49 or greater, so our attic was woefully underinsulated. Making matters worse, according to Oak Ridge National Laboratory studies, loose-fill fiberglass under cold conditions can lose as much as half of its nominal R-value due to convection currents in the insulation.

Before I invested in insulation, I used the Insulation Upgrade Calculator to estimate the savings (see Access). Measure the depth of the existing insulation in your home carefully and input the corresponding R-value—it will make a big difference in the savings you calculate. (If your attic is uninsulated, the Notes section on my Insulation Upgrades Calculator Web page can help you estimate the R-value.)

Based on the Calculator's results and local practice, we added 7 inches of blown-in cellulose insulation over the existing fiberglass loose-fill insulation to raise the R-value in the attic to about R-47. We decided to use cellulose because it has a higher R-value per inch than fiberglass, and does not allow the internal convection currents that reduce R-values in fiberglass insulation. We also feel that cellulose is an environmentally friendly choice, since it's made primarily from recycled paper products.

Before starting your project, be sure to properly seal around all penetrations, including pipes, conduit, and ducts—it will save you lots of work, and the itchy mess of digging through inches of insulation, afterward. Also be careful to avoid blocking vents and can-style lighting fixtures.

Project 2: Amending Attic Insulation

Up-front Cost: $256

DIY Labor: 6 hrs.

DIY Difficulty: 3 (on a scale of 10)

Annual Energy Savings: 1,593 KWH

First-Year Energy Cost Savings: $126

Projected 10-Year Savings: $2,006

Annual CO_2 Reduction: 812 lbs.

Insulating the attic saves 812 lbs. CO_2 per year

Insulating the crawl space saves 558 lbs. CO_2 per year

...And Underneath

According to the DOE, insulating crawl spaces and underneath floors can save an additional 5 to 15 percent on heating costs. The 25- by 15-foot, 4-foot-tall crawl space that occupies about a quarter of our home's footprint was originally vented to the outside. The floor above the crawl space was also uninsulated. By sealing the vents and laying a polyethylene moisture barrier over the dirt floor, we converted the crawl space to a conditioned space and boosted the efficiency of our furnace and ducts, which run through the crawl space. All the joints in the polyethylene are overlapped and sealed. Two-inch-thick rigid foam insulation is attached to the inside of the concrete walls, and the rim joists are insulated with rigid foam and fiberglass batts.

In our situation, this strategy is more effective than insulating the floor above the crawl space. First, it's less work. It also reduces the possibility of moisture problems developing in the crawl space, eliminates any plumbing freezing issues, and keeps the furnace and ductwork in a conditioned space that experiences fewer temperature extremes.

Project 3: Insulation in the Underbelly

Up-front Cost: $210

DIY Labor: 8 hrs.

DIY Difficulty: 4 (on a scale of 10)

Annual Energy Savings: 1,094 KWH

First-Year Energy Cost Savings: $86

Projected 10-Year Savings: $1,377

Annual CO_2 Reduction: 558 lbs.

Dealing with Ductwork

In buildings with forced-air heating and cooling systems, the network of ducts in a home's walls, floors, basement, attic, and ceilings carries conditioned air to the rooms. Most systems, unless they're relatively new, are uninsulated or insulated improperly. Uninsulated and leaky ducts translate into energy and dollars down the drain. Studies indicate that conduction losses and leaks from the average ducted air distribution system reduce overall system efficiency by about 30 percent.

Insulating and sealing ducts is especially important if they are located in unconditioned, unheated spaces. Minor duct repairs are generally easy to do yourself. First look for sections that should be joined, but have separated, and then look for obvious holes. Seal your ducts with Underwriters Laboratories (UL) certified mastic to ensure a long-lasting bond. Insulating ducts in a basement will make the basement colder, so if both ducts and the basement walls are uninsulated, consider insulating both. To help prevent condensation on cooling ducts, make sure that a well-sealed vapor barrier exists on the outside of the insulation. In most climates, use duct wrap insulation of R-4 or R-6.

I spent about $20 to seal all the ducts I could get at with duct mastic, and insulated the remaining uninsulated ducts in the attic and crawl space. This easy and inexpensive project more than triples its original investment in savings in less than a year. My cost-savings estimations are conservative—your savings may be much more depending on the condition of your duct system.

Sealing ducts saves 479 lbs. CO_2 per year

Project 4: Sealing Ductwork

Up-front Cost: $20
DIY Labor: 4 hrs.
DIY Difficulty: 3 (on a scale of 10)
Annual Energy Savings: 940 KWH
First-Year Energy Cost Savings: $75
Projected 10-Year Savings: $1,184
Annual CO_2 Reduction: 479 lbs.

Window Wrapping

Leaky, single-pane windows, and even double-pane units, can lose lots of heat and make heating bills soar. Most of us have tried the hair-dryer-and-shrink-wrap plastic window seal, which helps stop infiltration. But an easier (and somewhat cheaper) method for reducing heat loss through window glazing is to provide additional insulation. I had read about bubble-wrap being used in greenhouses to reduce winter heat loss, and decided to try it on some of the windows we don't need to open during the cold months.

Wrapping windows saves 487 lbs. CO_2 per year

I found that bubble-wrap packing material can be an inexpensive improvement for window efficiency. Being an engineer with a new infrared meter to test, I measured windows with and without bubble wrap, and determined that the wrap adds about R-1 to the windows.

Installation is easy and quick—simply cut a sheet of wrap to match the glazing, mist the glazing with water, and smooth the bubble-wrap over the window. Usually, one spray is enough to secure the bubble-wrap to the window for the full heating season. Although the bubble-wrap distorts the view, it still allows ample daylight to pass through.

At the end of winter, you just pull the bubble-wrap off, roll it up, and save it for next year. This simple solution is very cost effective—payback is usually less than one heating season—and is worth doing even if you plan to do something fancier in the future.

Project 5: Bubble-Wrapping Windows

Up-front Cost: $38 (or free)
DIY Labor: 3 hrs. (there's a little learning curve the first time)
DIY Difficulty: 2 (on a scale of 10)
Annual Energy Savings: 955 KWH
First-Year Energy Cost Savings: $75
Projected 10-Year Savings: $1,202
Annual CO_2 Reduction: 487 lbs.

A Step in the Right Direction

When Joan and I officially began the Half Plan, we decided to tackle the projects that offered the most energy savings per dollar spent for our climate, house, skills, and habits. After only two years, the savings have been phenomenal.

From simple projects like these, which require little to no up-front investment, to bigger investments, such as replacing our car with a hybrid-electric Toyota Prius, we'll save about $4,600 in energy costs and prevent 20 tons of CO_2 from being emitted—*every year.* Of course, as electricity and fuel prices continue to climb, our financial savings become even greater. And that's a (half) plan we can really get behind!

Access

Gary Reysa, Build It Solar Projects • www.builditsolar.com • Details on energy savings calculations

"The Half Plan—Reducing Your Carbon Footprint. Part One: Thermal Gains," Gary Reysa, *HP118*

"The Half Plan—Reducing Your Carbon Footprint. Part Two: Trim Your Waste Line," Gary Reysa, *HP119*

Carbon Calculators
Infinite Power • www.infinitepower.org/calculators.htm

Safe Climate • www.safeclimate.net

Project Evaluation Links/Software:
DOE Recommended Insulation Levels • www1.eere.energy.gov/consumer/tips/insulation.html

Home Energy Saver • http://hes.lbl.gov/ • Online DIY home energy audit

Insulation Upgrade Calculator • www.builditsolar.com/References/Calculators/InsulUpgrd/InsulUpgrade.htm

Online Insulation Assessment: ZIP-Code Insulation Program • www.ornl.gov/~roofs/Zip/ZipHome.html

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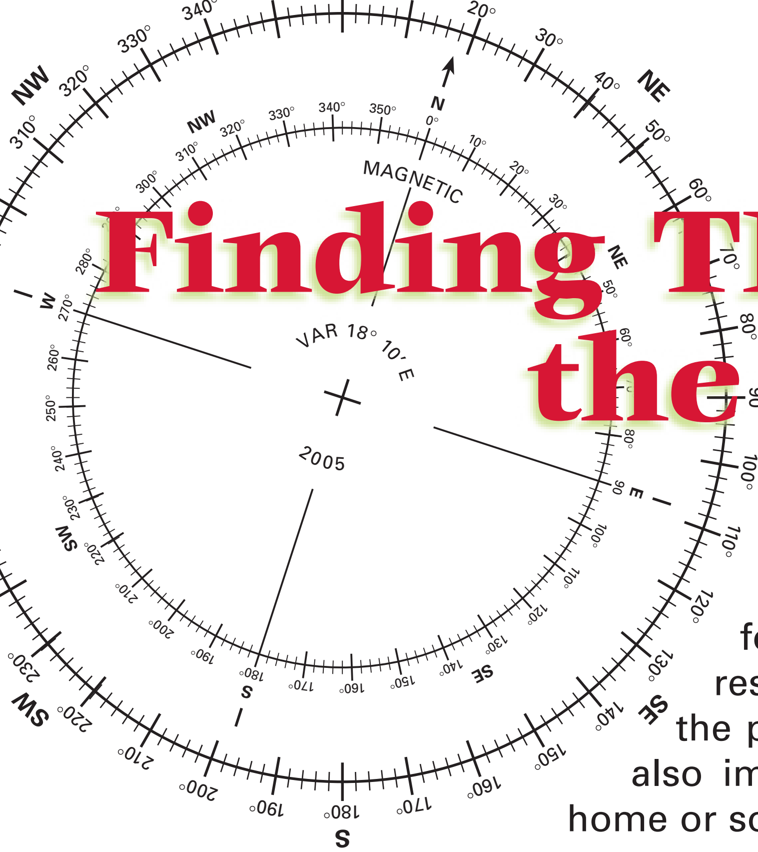


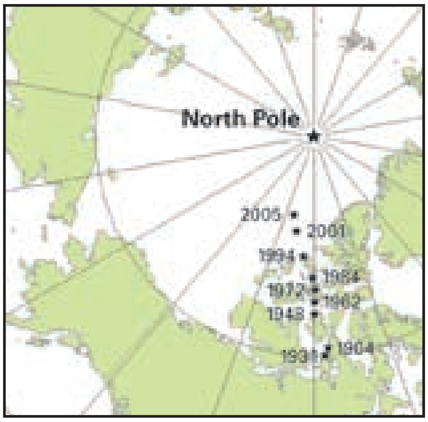
by Grey Chisholm

Finding TRUE South the EASY Way

Proper layout of passively heated homes, photovoltaic (PV) systems, and solar thermal systems is important for getting the most out of your solar resource. Not only is it imperative to use the proper tools for evaluating shading, but also important is the proper orientation of a home or solar collector relative to true south.

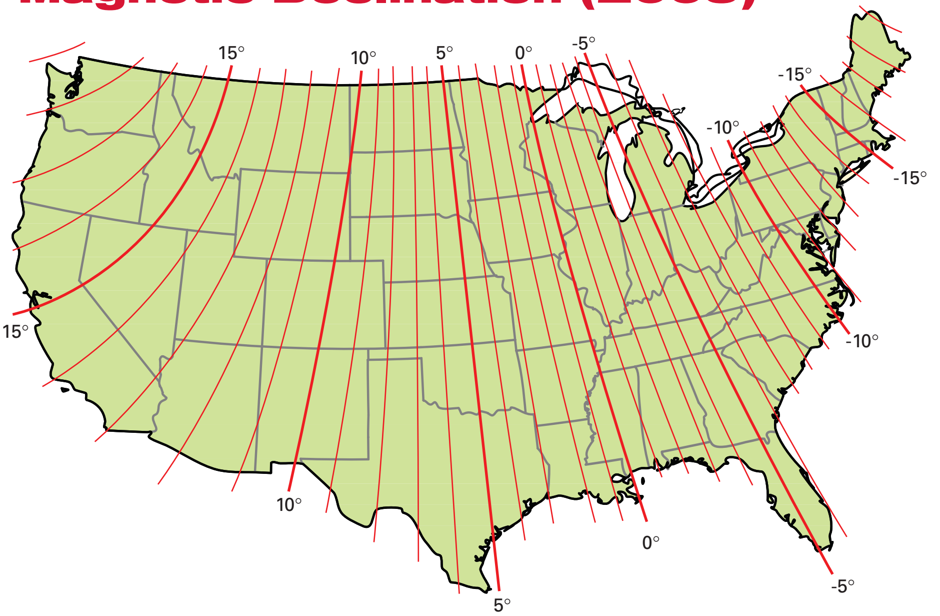
PV systems sited within 10 degrees of true south lose a maximum of only 2 percent of their generating capability. (For math-oriented people: The cosine of 10 degrees is approximately 0.98.) This doesn't sound like much, but considering the cost of PV modules, finding that extra "free" 2 percent can be worthwhile. Passive solar homes and solar thermal systems can show similar gains from accurate orientation.

But few people I encounter—even those with lots of solar energy experience—understand the differences between true, magnetic, and compass north (or south). And many solar energy system designers use only magnetic declination (a location's difference between magnetic and true north) to determine true south, without realizing that this gives only part of the picture—and that the solar orientation might be farther off than they think.



Magnetic north moves over time.

Magnetic Declination (2005)



As a professional mariner, I work intimately with the difference between true north and magnetic north on a daily basis, and know that, in the northern hemisphere, there is an easier and more accurate way of determining true south than is usually discussed.

Decline

Two components determine the difference between true north and what the compass reads: magnetic declination and magnetic deviation. Magnetic declination is the difference between true north and magnetic north based on geographic location, and is

approximated in commonly found magnetic declination maps. Current theory is that the spinning, molten iron core at Earth's center creates an electromagnetic field. Since the magnetic field is not exactly lined up with Earth's axis (North and South Poles), there is a geographic difference between the true poles and the magnetic poles. Compasses are basically magnets that point as closely as they can toward the magnetic poles.

Magnetic declination changes slightly over time as the magnetic pole moves, but is easy to determine by using the National Oceanographic & Atmospheric Administration Web site (see Access). For example, my house's magnetic declination is 9 degrees 34 minutes east (E), and has been changing by 0 degrees 7 minutes west (W) per year (1 minute of arc equals 1/60 of a degree). Magnetic declination can either be east of north or west of north, which further complicates the procedure—be sure to get the direction correct or else your orientation could be off doubly far.

Deviate

Magnetic declination is only one of the potential orientation errors. Magnetic deviation is the difference between magnetic north and what the compass reads, or compass north, and is induced in a compass by *local* magnetic fields. Deviation must be taken into account along with magnetic declination if accurate bearings are to be calculated.

Just like magnetic declination, magnetic deviation can either be east of north or west of north. And it can be the same or opposite of magnetic declination. Local magnetic fields that can contribute to deviation include:

- The metal parts of the compass or the ship or vehicle it is traveling in
- Variations in Earth's magnetic fields caused by differences in Earth's crust and mantle
- Variations caused by mountains, iron ore deposits, etc.

While geologic variations like iron ore deposits near your site can cause deviation, it is most commonly caused by iron, steel, or magnets near where you are measuring. And deviation calculations can change from measurement to measurement! Most likely, *you* are causing the deviation. How far away is your vehicle? Are you carrying a wrench or hammer? Most audio speakers have a magnet in them; do you have a cell phone or radio at hand? Is the solar array's post made of steel? Steel, a magnet, or any magnetic field from electrical equipment can deflect the needle of a compass you are using.

Luckily, it is easy to address most deviation by removing the source or bypassing it. Move your truck farther away. Leave all your metal tools several meters from where you are measuring. Stand at least a few meters from the steel post the array is mounted on.

To determine magnetic north, you must apply deviation effects to what your compass reads. Then you apply magnetic declination to magnetic north to get true north. Again, each correction can be east or west, so be sure to add or subtract correctly. As you can see, determining true south can become quite complicated!

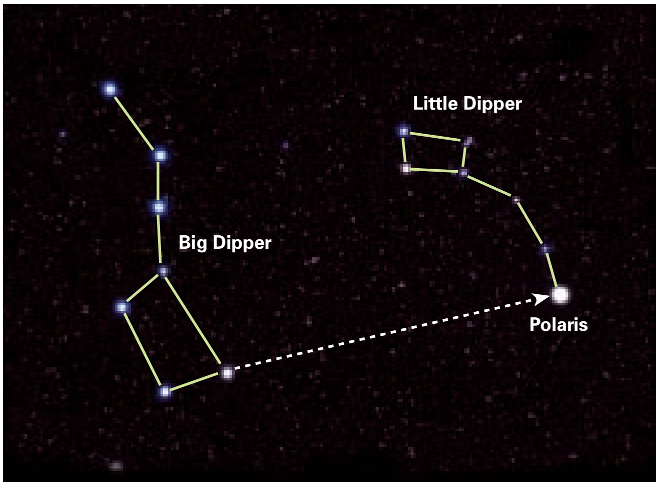
Q: Which of the elements in this scene can negatively affect the accuracy of a compass? A: Lots of them.

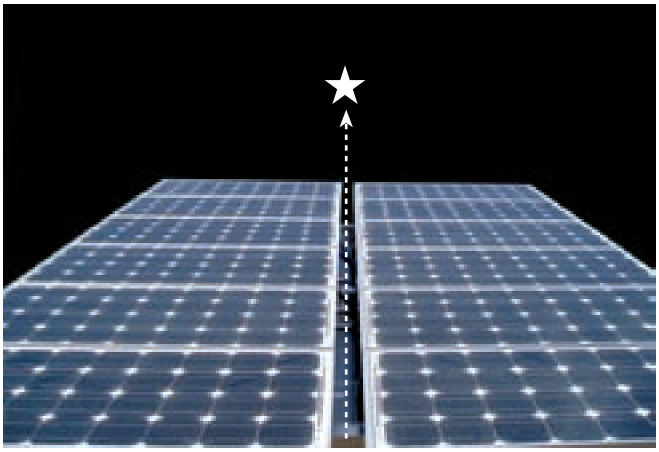
The Easy Way

You might be surprised to learn that the most accurate method of determining true north completely bypasses magnetic deviation, magnetic declination, and all that calculating—and eliminates the compass altogether.

Just look up in the sky on a clear night. In the northern hemisphere, you will see Polaris, the North Star, stationary in the sky. The North Star is always either exactly or just a few tenths of a degree from true north. So all you need to do to face your system south is line up its north/south axis with the North Star. How do you find it? Look north (use your compass and allow for magnetic declination). The North Star is not the brightest star in the sky, but it is the brightest in that *part* of the sky. If you know what the Big Dipper looks like (take a look at Alaska's state flag), follow the two pointer stars on the outside of the Big Dipper's cup to find the North Star.

Recognizing the Big and Little Dippers can help you identify Polaris, the North Star.





Aligning an array to true south by siting the North Star.

Case in Point

Before my partner Michele and I built our house, we had the solar-electric system installed so we could use solar energy for most of the home's construction. After the modules were installed, I went out on a clear night to check the array's orientation. Sure enough, the PV array had been installed about 15 degrees off true south. So I loosened the bolts and swung the array until the North Star lined up with the space between the left and right halves of the array. After retightening the bolts, the array was positioned to harvest 100 percent, not 98 percent, of the sun's power.

I also used a similar method before our home's foundation was laid. On a clear night, I went out to the site, pounded a tall fence post into the ground, and walked south-ish about 50 feet. Then I squatted down and moved a little until I lined up the North Star with the top of the fence post, and set a second post at this location. After double-checking the alignment, I had a positive reference for a true north–south line. I didn't need to use any calculations, and I didn't worry about magnetic deviation from iron ore, steel posts, or my cell phone. My contractor simply used the two reference posts to properly orient our passive solar house to true south.

Finding true north is easy, so why make it harder than it needs to be? And once you know true north, since true south is off by 180 degrees, you know it too—just turn around. Next time you need to do the important task of orienting a building or solar panels to true south, simply wait for a clear night and let the North Star be your guide.

Access

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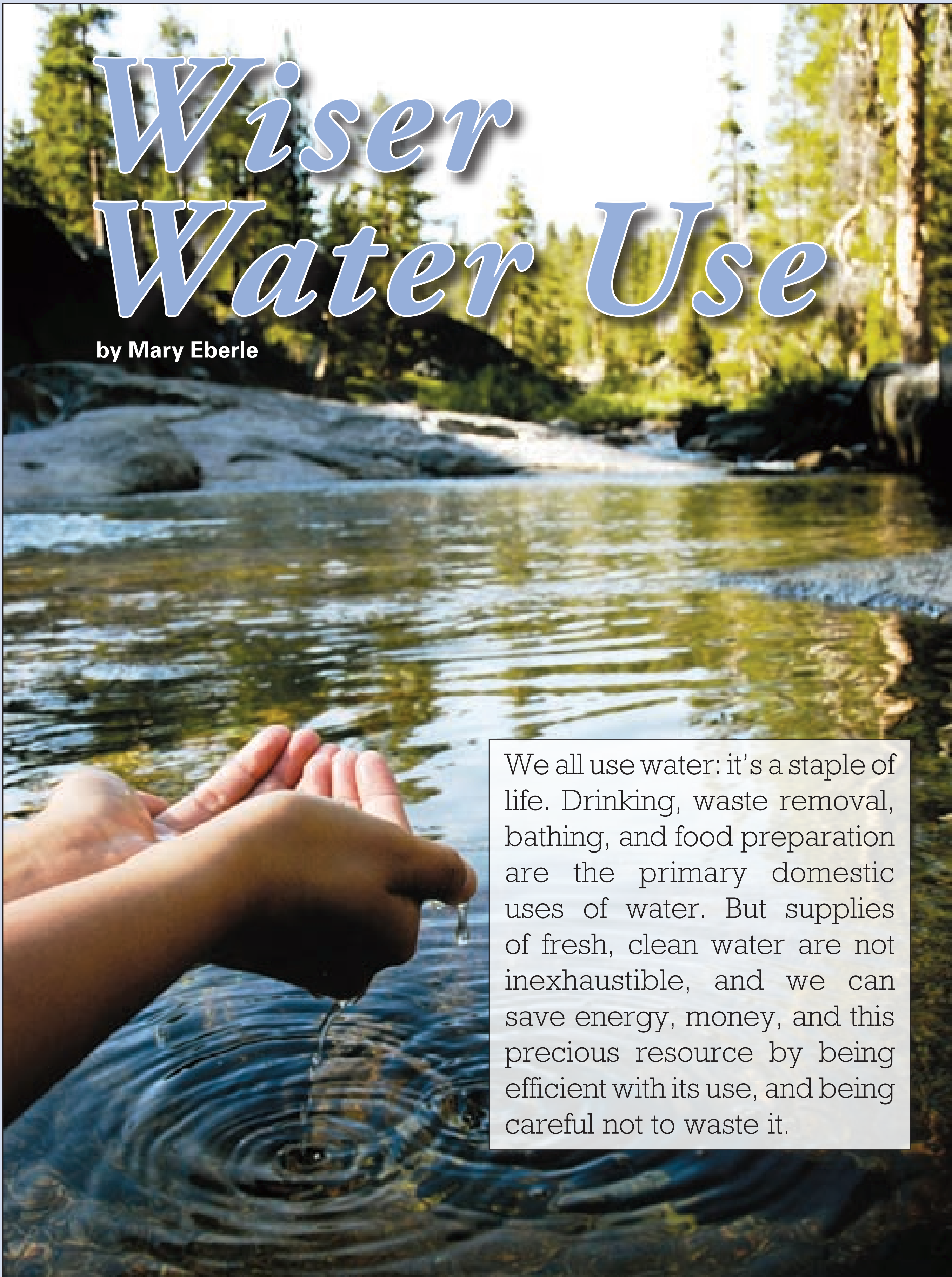
NOAA • www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp • Magnetic declination calculator

U.S. Geological Survey's National Geomagnetism Program • http://geomag.usgs.gov

Wiser Water Use

by Mary Eberle



Eric Hood/www.erichood.net

We all use water: it's a staple of life. Drinking, waste removal, bathing, and food preparation are the primary domestic uses of water. But supplies of fresh, clean water are not inexhaustible, and we can save energy, money, and this precious resource by being efficient with its use, and being careful not to waste it.

In some places, water is so scarce that it is obtained from hundreds of miles away. Even where water has been plentiful in the past, groundwater levels are dropping, and some creeks and rivers are disappearing from the mounting pressures of drought, irrigation, and population growth. For example, in both 2005 and 2006, the Little Plover River, just outside of Stevens Point, Wisconsin, dried up due to extensive agricultural and municipal water use. Because of overappropriation for irrigation and other water uses, the Rio Grande, along the U.S.-Mexican border, is reduced to a mere trickle by the time it reaches the Gulf of Mexico.

According to the American Water Works Association, the average household uses 69.3 gallons per day (more than 25,000 gallons each year) for indoor purposes. By installing water-efficient fixtures and eliminating leaks, households can reduce this by 35 percent or more. Here is how you can reach that goal and do more, with less.

A leak dripping at one drop per second wastes 2,700 gallons per year.

Repair the Leaks

One easy way to stop wasting water is to repair leaky faucets, showerheads, pipes, and toilets. A leak dripping at one drop per second wastes 2,700 gallons per year. Dripping faucets can be fixed by replacing washers in the valve seat. (For details on how to fix leaky faucets, toilets, valves, etc., see Access.)

To check for toilet tank leaks, place food coloring in the toilet tank and wait about 30 minutes. If the color shows in the bowl without flushing, the tank is leaking. You may find a leaky flapper valve to replace, or that you need to make an adjustment in the float valve to decrease the water level to below the overflow tube—both are easy to fix. When finished testing, flush the toilet to clear the food coloring, as it may stain the bowl.

Some plumbing leaks may be hidden under the home, underground, or even inside a fixture, and can be detected by reading a water meter before and after a two-hour period when no other water is being used. If the meter does not read the same as the first time, there is a leak that must be searched out and repaired.

Saving Water = Saving Energy + Money

Whether water is supplied by a private well or a municipal water system, it takes energy to move it from source, to storage, and to the end use. The less water consumed, the less energy needed to pump it.

The same goes for heated water—less consumed means less energy needed for heating. Turning down a water heater thermostat is one way to cut water heating costs and energy use. Each 10°F reduction in water temperature can shave 3 to 5 percent off water heating costs. Temperatures can be set as low as 115°F, providing adequate hot water for uses such as hand dishwashing, showering, and bathing.

Laundering clothes in cold water can also save energy. Implementing hot water conservation strategies before you size a solar hot water system for your home can save money on a system's costs.

Water conservation techniques save money too, particularly in homes served by a public water utility. Conserving water saves on water and sewer bills, which often include both a fixed charge and a per-gallon charge, such as $2.80 per 1,000 gallons of water. Although this charge might seem trivial, conserving water can provide excellent financial savings over the long term.

Example Water & Cost Savings

Type	Kitchen Aerator Flow (GPM)	+	Shower Head Flow (GPM)	=	Total (GPM)	x	Time On (Min. / Day)	=	Total Daily Usage (Gal.)	Total Annual Usage (Gal.)	Annual Water & Sewage Cost*
Regular	3.50		3.50		7.00		30		210.0	76,650	$215
Low-flow	2.20		1.75		3.95		30		118.5	43,253	121
Savings	1.30		1.75		3.05		30		91.5	33,397	$94

*At $2.80 per 1,000 gal.

Toilet Training

Older toilets use 3.5 to 7 gallons per flush (gpf) and account for about 40 percent of all indoor household water use. They can be replaced with low-flow versions that use 1.6 or fewer gpf, saving about 15,000 gallons of water a year. Although some early low-flow toilets had problems flushing completely, toilets have been re-engineered to perform properly with a 1.6-gallon flush.

Another option is a dual-flush toilet, which allows you to choose the amount of water to use, either 0.8 gallons or 1.5 gallons for heavier needs. Duals are mandated in some countries, and are increasingly available in the United States, costing $270 to $620.

Water-wasting toilets can be retrofitted to save water by installing an adjustable flapper valve, a toilet tank bank, and/or an overflow tube diverter. Adjustable flapper valves have an opening that lets water in to weigh it down. A weighted flapper valve shuts sooner than a non-weighted one, allowing less water to flow from the tank to the bowl and saving up to 3.0 gpf. This inexpensive flapper valve (about $5) is particularly useful in traditional toilets, but also can be used in some low-flush toilets.

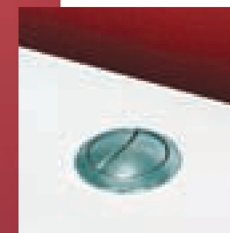
A toilet tank bank is a bladder filled with water and hung in the tank. It displaces space that would normally be filled, so each flush uses less water. A bank (about $2) can save up to 0.8 gpf. Beware: Although a toilet tank bank is sometimes called a "glorified brick," a real brick in the tank can deteriorate and damage a toilet's flushing mechanism. Other items placed in a tank may dislodge and catch the flapper valve open, causing the toilet to "run" continuously—the opposite of the desired result.

A toilet fill-cycle diverter ($1) mounts on top of the tank overflow tube and is connected to the fill tubing. A hole in the diverter redirects some of the water from the overflow tube into the tank, saving excess water from being sent into the bowl. These gizmos can save 0.5 gpf.

In Japan, where space and potable water are both scarce, some toilets incorporate sinks into tank lids. Clean water normally sent to the toilet tank is diverted to the sink's spigot for hand-washing, and then routed to the tank—performing two functions before it's flushed. A replacement lid with a sink is available in the United States for $89 (see Access).

A composting toilet is an option when water is particularly scarce. (Note: Most use no water, but some require electricity to evaporate the liquid waste.) Composting toilets use bacteria to break down waste, converting human "manure" into an odorless, nutrient-rich fertilizer suitable for amending the soil around nonedible plants. Dry material, such as sawdust, is added to reduce odors and control insects. Composting toilets can reduce indoor water use by up to 30 percent, and manufactured models start at about $1,200. (Some people choose to construct their own.) Check your local regulations to ensure that they are allowed, or if regular inspections are required.

Other waterless toilets incinerate the solids and evaporate the liquids, leaving only ash. These toilets are energy-intensive, using 14 to 17 KWH per day for two people—as much as many energy-efficient households use in total—and start at $1,600.



A dual-flush toilet lets you choose how much water to use.

Courtesy www.totousa.com

A low-flow toilet can greatly reduce your water use.

A weighted adjustable flapper valve.

A toilet tank bank displaces space in the tank, saving water with each flush.

Double duty: This toilet-lid sink cleverly routes used hand-washing water to the toilet tank for future flushes.

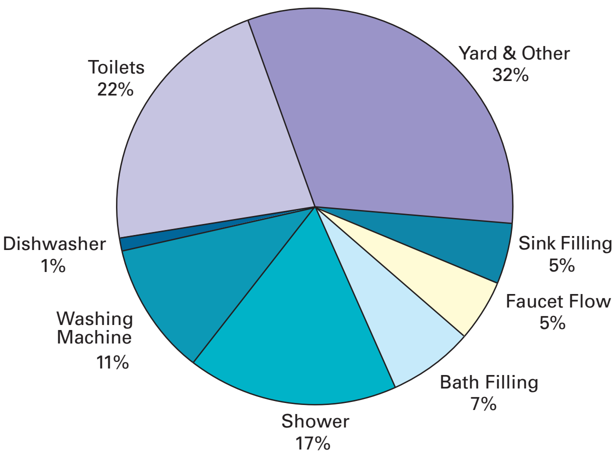
Courtesy www.sinkpositive.com

Showers & Faucets

Standard showerheads use up to 10 gallons per minute (gpm), but low-flow showerheads typically use one-tenth to one-fourth that much. A low-flow showerhead works by mixing air into the water flow, which is restricted to increase the water velocity, resulting in the use of less water to rinse. Some come with shut-off valves so you can turn off the water while soaping up, then turn it back on to rinse without having to readjust the temperature settings.

Faucets can be easily fitted with low-flow aerators for less than $3. Traditional faucet aerators typically use 3.5 gpm. Low-flow faucet aerators use 1.5 to 2.2 gpm and are available for the kitchen or bathroom.

Typical Household Water Usage



Low-flow faucet aerators for the bathroom (left) and kitchen (right) are inexpensive water savers.

Saving Water Outdoors

Lawns, gardens, and other outdoor applications of water account for the largest portion of household water use—about 30 percent. This makes the outdoors a prime target for conservation.

A relatively new method of outdoor water conservation is xeriscaping, a strategy of creating a landscape that thrives on the amount of rainfall nature provides. Water-wise landscapes tend to be more resistant to diseases, easier to maintain, and more welcoming to pollinating butterflies, birds, and bees.

Here are some other outdoor water conservation methods you can use:

Courtesy Black & Veatch

- Mulch around plants and trees to reduce water evaporation. Mulch materials include wood chips, straw, plastic film, and landscape fabric.
- Use plants adapted to local conditions. In arid climates, yucca, iris, thyme, and crocus fare well. Consider using native plants, which are already adapted to the local climate.
- Water in the early morning, when it's less windy and cooler, to avoid evaporation.
- Add windbreaks and fencing to slow winds and reduce evaporation caused by moving air.
- Decrease the size of your lawn. One square foot of lawn can require an inch of water (0.6 gallons per sq. ft.) per week during the summer.
- Make sure your soil's porosity matches your plants' needs. Plants that are rooted in soils with high porosity will be continually thirsty, and low porosity soils can hold too much water, drowning the roots.
- Irrigate efficiently by targeting water directly to your plants and trees with drip systems or soaker hoses.
- Use a rain barrel or tank to harvest runoff from your roof, and use that "free" water for your yard.

Energy Star washing machines can save water and energy.

Washing Machines & Dishwashers

For washing clothes and dishes efficiently, choose Energy Star models. Full-sized Energy Star clothes washers use 18 to 25 gallons of water per load, compared to the 40 gallons used by a standard machine. They also save up to 50 percent in energy costs, and extract more residual water to shorten drying time.

Energy Star dishwashers are designed with more efficient motors and washing action, saving about 4 gallons of water per cycle while ensuring effective cleaning. And they use at least 41 percent less energy than the federal minimum standard for energy consumption. Both dishwashers and washing machines also save on hot water, furthering energy savings.

Quick Conservation Tips

Habitual water saving comes easy with practice. Here are some simple conservation techniques you can implement:

- While brushing your teeth or lathering your skin, minimize water consumption by simply turning off the faucet between uses.
- While the faucet is on, try to use the water for at least two purposes, such as washing hands and presoaking dishes in a basin.
- While waiting for water to heat up at the tap, collect it in a vessel and find other uses for it, like watering plants.
- Used water, called greywater, can be collected from dishwashing, laundry, and bathing, and used for watering houseplants or gardens. (For more info, see Access.)

Capturing Rainwater

Instead of sending rain runoff from your roof or driveway down storm drains, where it carries washed-off chemicals and other pollutants to lakes and rivers, capture it on site. Besides protecting watersheds, you'll also be helping recharge groundwater tables that have fallen, in part, because of the increase in impervious surfaces.

Build a rain garden to help intercept runoff that might otherwise go down storm drains, and provide greenery in your landscape without additional watering. Native perennial plants are typically used because of their ability to develop extensive root systems and tolerance of varying moisture conditions.

Rain barrels can also reduce storm-water runoff by capturing it before it has a chance to hit the ground. Rain falling on a roof can be directed through gutters and downspouts to rain barrels, which have a spigots for delivering collected rainwater. You can use this collected rain to water a garden or wash a car, reducing your demands on your household water supply.

Dave Stroble

Access

Mary Eberle, First Step Renew, 417 Walton Pl., Madison, WI 53704 • 608-441-0044 • admin@firststeprenew.com • www.firststeprenew.com

Additional Resources:

Composting Toilet World • www.compostingtoilet.org • Composting toilet information

Environmental Design Works • www.sinkpositive.com • Toilet-lid sink

Repairing leaks • www.wikihow.com/Category:Plumbing-Drains-Wasteand-Vents

Univ. of Massachusetts Extension • www.umassgreeninfo.org/fact_sheets/plant_culture/gray_water_for_gardens.html • Greywater gardening

Wisconsin Department of Natural Resources • www.dnr.state.wi.us/org/water/wm/nps/rg/rgmanual.pdf • Excellent rain garden guide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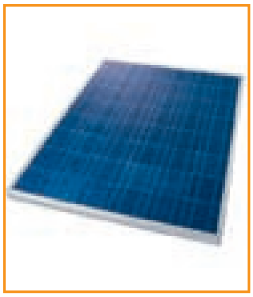

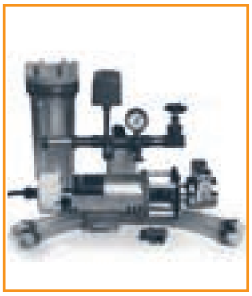

POSTMODERN PV PIONEERS

Off Grid & All Sunshine

by Ian Woofenden

Everyone has heroes. Jennifer and Lance Barker are some of mine. They've managed to do what my family has done—live without utility electricity for decades—but without relying on nonrenewable fuels for cooking, space heating, or backup electricity. Here's how these two postmodern pioneers meet their energy needs—using electricity solely from the sun.

Postmodern pioneers Jennifer and Lance Barker put the sun to work on their homestead.

Left: A 5-kilowatt solar-electric array provides the homestead with electricity, as well as powers pumps that irrigate Lance and Jennifer's extensive vegetable gardens (above).

Fossil-fuel generators and propane have long been "enablers" for off-gridders. Generators provide the convenience of abundant energy without having to spend a fortune up-front on renewable generation capacity, and they minimize the need to change energy use habits. But an off-grid "renewable energy" lifestyle has its contradictions when it can't be pulled off without the fossil-fuel crutch—after all, how much independence is really gained by getting off the electricity grid only to jump on the propane, gasoline, or diesel bandwagon?

When I first met Lance and Jennifer, and heard how they had gradually developed their rural, off-grid homestead without relying on a backup generator, I was intrigued—and envious. I remembered the thousands of dollars I'd spent on generators, fuel, and repairs. I remembered the hundreds of hours I'd spent dealing with noisy, smelly, stubborn generators. And I still wonder what my renewable energy (RE) systems would look like today if I'd invested all that time and money spent on generators, fuel, and maintenance into more renewable generation capacity instead.

Lance and Jennifer's homestead and energy systems evolved over time in a thoughtful and organic way—a reflection of their life philosophy that has been very purposefully shaped around the sun, optimizing its usefulness, and maximizing their independence from fossil fuels. Their success spans not only their fossil-fuel-free energy supply, but also their ability to grow, process, and store the majority of their food, further reducing their reliance on the nonrenewable fuels required by conventional agriculture.

FOLLOWING THE SUN

Lance first encountered solar electricity and the idea of renewable energy in high school science class, and was immediately captivated by the independence it offered. So when he struck out on his own, he searched specifically for off-grid property where he could establish a self-sufficient homestead. Inspired by his father, who restored worn-out Kansas farms to native grass pasture, Lance found 40 acres of overcut, overgrazed pine forest in the southern Blue Mountains, near Canyon City in Grant County, Oregon, and put his roots down.

With only 1.7 people per square mile, Grant County is the size of Connecticut in land area, but has only 8,000 people—so it's intensely rural. Lance picked this area for its clean land, air, and water, and for its solar potential—more than 250 days of sunshine per year. About ten families live in the Barkers' neighborhood, and they're evenly split between those who have punched the grid in, and those who live off grid. He watched his off-grid neighbors throw money and time at generators, and wasn't interested in the hassle or expense

Well-placed meters inside their home provide Lance and Jennifer with immediate feedback on the status of their PV system.

The Barkers' pole-mounted PV system has grown from one 32-watt module in 1979 to a 5,000-watt array using 44 modules today.

Beyond PV

Lance and Jennifer dedicate their lives to using the sun and promoting its usefulness. Jennifer is founder and executive director of EORenew, a nonprofit organization that coordinates the annual SolWest Renewable Energy Fair in John Day and provides ongoing energy education in eastern Oregon. Lance designs and installs solar-electric systems for both on- and off-grid clients. A large and enjoyable part of his business is building small stand-alone PV power and control systems for fish screens. The solar-powered DC motors clean debris off the screens, which keep fish from entering stream-fed irrigation ditches.

As much as possible, Lance and Jennifer work from their home office and workshop, which allows them to keep their life centered on developing their self-sufficient homestead and reduces their reliance on fossil fuels for transportation. Lots of time at home enables them to use the sun's energy for more than just generating electricity for the household, pumping water, and growing their food. Jennifer is somewhat of a solar cooking guru, after years of solar cooking, teaching workshops, and publishing two cookbooks. Lance is just learning how to cook with the sun. "I find solar cooking is easier for inattentive cooks like me," he says, "because if the cooker is neglected, the sun goes by, and the dish cools down, instead of burning as it would on a conventional stove."

The sun also provides energy for another important part of the Barkers' life—restoring the second-growth pine forests on their property to an old-growth ponderosa pine plant community. The Oregon Tree Farm System named them "Oregon Tree Farmer of the Year" in 2000, and the governor of Oregon cited their restoration project as one of Oregon's best examples of sustainable forestry.

of importing propane for cooking and heating either. From the start, Lance was committed to developing a system that would produce all of the homestead's energy on site, and to living within the energy "budget" that the sun provided.

SOLAR EVOLUTION

Lance moved onto the property in 1979. In the late 1970s, residential solar-electric equipment was in its infancy, very expensive—and beyond Lance's budget. Connecting to the grid was expensive and outside of his scope for a self-sufficient homestead. So Lance chose to live with no electricity at all, until he saved enough money to buy his first Arco 32-watt (W) solar-electric (photovoltaic; PV) module. With this small system, he ran a single DC fluorescent light, and "never had to buy kerosene again for the lanterns."

Jennifer joined Lance on the land in 1991, after already spending some time living off-grid with a one-module DC system at her ski lodge in the Cascades. Over the years, they have slowly grown their solar-electric system. Living within the limits of the solar energy they could harvest gave them increased economic flexibility. They added to their system when the money was available, and during lean times, didn't put any money into it at all. Folks who rely on propane and generators don't generally have this option—they are dependent on continually purchasing fuel.

Along with increasing the capacity of their PV array, the Barkers also purchased newer, higher performance inverters and controllers as they became available. "Our system was pretty much built that way, one step at a time," says Lance. "Since I'm not an inventor, everything we do is with off-

As the PV array expanded, so did the Barkers' power center. Although some of their primary loads are DC, three inverters (left and below) also convert the PV array's output for standard AC appliances.

Left: Comfortable, efficient country living.

Below: Jennifer takes advantage of the sun's free energy to cook delicious meals in their solar ovens.

the-shelf equipment." Over 28 years, the system has slowly grown to 44 modules—and 5,000 watts (5 KW) of solar-electric independence.

For space and water heating, as well as cooking, Lance and Jennifer use wood they harvest from their sustainably managed woodlot. "Biomass accumulates here faster than it decomposes," says Lance. "This material is going to burn—and we get to choose how and when! So we have wood for ample thermal energy here, and that makes it easier for us to avoid using propane." Their modest-sized, passive solar home is built to take advantage of solar gain in winter and is well insulated. Plus, Jennifer says, "Any time I'm cooking on the woodstove, it's producing enough heat for our small house." A coil in a Pioneer Maid wood cookstove produces hot water for domestic use.

GENERATOR-FREE

Lance and Jennifer took a hard line on having a generator—they just didn't do it! Instead, they invested all the money that they didn't spend on generators, generator sheds, fuel, and maintenance into expanding the PV system. The guiding principle they used to develop their RE system is in many ways 180 degrees from the standard design approach used for off-grid sites. "It's what we call production determination of a system," says Lance, "rather than load determination. You produce electricity, and that's how much you have available to use. It's not really a difficult concept, but it's very different from the normal North American way of doing things."

Lance sums up their basic philosophy: "We have adequate solar-electric capacity to support our base loads, and we add to those base loads only as we can afford to add to our array." The Barkers' base load (and dates of installation) consists of these individual energy uses: lighting (1981), water pumping (1982), refrigeration (1984), computers (1991), and a chest freezer (1994). These total 1.2 KWH per day, including losses from battery inefficiency. Over the years, the Barkers have been able to reduce their base load by switching from an AC Vestfrost to a DC SunDanzer freezer that uses less energy and doesn't incur additional inverter conversion losses. Beyond the base loads, Lance says, "All other electrical loads—of which we have many—are discretionary, depending on energy availability. That philosophy has remained the same, even though our system has expanded in ways that were unimaginable in the beginning, because the hardware simply did not exist."

At critical junctures in their equipment upgrades, Lance and Jennifer had to examine the future of the system. They knew that most modern off-grid systems exclusively use AC appliances due to the wide selection of models available and to simplify home wiring during

Overview

System type: Off-grid, battery-based solar-electric

Location: Near Canyon City, Oregon

Solar resource: 5 average daily peak sun-hours

Production: 560 AC KWH per month average

Photovoltaics

Modules: Forty-four BP 80s, 85s, and 170s; 80, 85, and 170 W STC; 12 or 24 VDC nominal, depending on module

Array: Fifteen, 2- or 4-module series strings (depending on module voltage), 5,000 W STC total, 48 VDC nominal

Array installation: UniRac, General Specialties, and home-made pole mounts; seasonal tilt: 55 degrees in summer, 90 degrees in winter

Energy Storage

Batteries: Single string of 12 Concorde PVX-6480T, 2 VDC nominal, 640 AH at 20-hour rate, sealed AGM

Battery bank: 24 VDC nominal, 640 AH total

Balance of System

Charge controllers: Two networked Apollo T80s, 80 A, MPPT, 48 VDC nominal input, 24 VDC nominal output

Inverters: OutBack VFX3524, Trace SW4024, Magnum MagnaSine, 24 VDC nominal input, 120 VAC output

System performance metering: E-Meter battery monitor and 9 analog meters

construction. But Lance says, "When we examined this carefully, we came to the conclusion that running DC loads for lights, refrigeration, and fans cuts the daily electric use significantly by eliminating the inverter losses, which may be 10 to 15 percent, or even more than 50 percent on a very small load like a single light." Using DC loads instead of AC ones saves Lance and Jennifer more than 200 watt-hours per day. In a generator-free, off-grid PV system, every watt-hour counts. Minimizing the base load is essential to ensuring an adequate electricity supply through cloudy stretches of weather. Lance points out that "because straight AC systems are the 'modern' method of having an off-grid system, we call our system 'post-modern,' because we are aiming for the future, not the past."

In his business as an RE consultant, Lance uses standard load analysis and sizing methods when he designs systems for off-grid customers. But his personal conclusions and lifestyle are different. "By setting limits to what Jennifer and I are able to consume, and living within these limits, we get a closer feel for what we are doing with our lives. It helps give our life purpose and meaning, and it helps make us happy. Our system is often called 'pure' or 'purist.' I see it as pure, all right—purely practical."

DESIGN LESSONS

Running a system like Lance and Jennifer's takes tools. Lance says, "Our most important tools for making our system work are our brains! Sometimes visitors look at what we do and say, 'I wouldn't want to have to think about it.' Well, we *do* want to have the opportunity to think about it and apply ourselves accordingly. Living without a generator gives us a close personal relationship with our energy use—how much energy is coming in and how much we are using."

Another essential tool is a battery state-of-charge monitor (amp-hour meter), which provides cumulative and net battery charge data. It is installed where Lance can see it when sitting in his easy chair. Along with the amp-hour meter, they also have analog ammeters so they can see at a glance how the system is running throughout the day.

When Lance and Jennifer replaced their more than 20-year-old battery bank four years ago, they found that their battery sizing philosophy had changed because of their previous investment in increased PV capacity. As more modules are added to an array with maximum power point tracking (MPPT), more electricity is generated during low-light, overcast, or partly sunny weather. The result is that even with the sun's limited availability on mostly cloudy days, the system's batteries often still receive a full charge. By watching their battery monitor over the years, Lance and Jennifer determined that they really didn't need the 800 amp-hour (AH) battery bank capacity they originally had (about 10 KWH of usable storage at 50 percent depth of discharge), and replaced it with a 640 AH bank, for about 8 KWH of storage (at 50 percent DOD).

SURPLUS ENERGY

The combination of a small base load, large PV array, and a very sunny location has enabled Lance and Jennifer to live off grid for close to three decades without any fossil-fuel-based backup energy source. During the winter months, this approach has continually provided them with ample electricity, when most off-grid system users would have to resort to firing up the engine generator to keep the batteries from being too deeply discharged. During the non-winter months, the PV array produces significant amounts of energy beyond what the base loads require.

When asked about managing the additional energy available during many months of the year, Lance responds, "For a long time, I thought that we would be able to buy off-the-shelf hardware to electrolyze water with our extra energy. Then we'd have hydrogen for instantaneous water heating and for summer cooking. It hasn't happened yet, but I try to remain hopeful that the equipment will someday become available."

For now, they use a different approach. During the growing season, once the batteries are charged, solar energy is used to pump a large daily volume of water to their extensive vegetable gardens and tree seedlings. Lance's irrigation setup pumps 1 gallon of well water for crops with each watt-hour of energy the PV system generates. Considering that the average meal in the United States travels about 1,500 miles before it hits the dinner table, both Lance and Jennifer are quick to point out that growing as much of their own food as possible has a huge

impact on the amount of petroleum they use. Having ample solar energy for water pumping makes this possible.

Their 40-acre Morning Hill Forest Farm produces much of their food and all the wood needed to heat their home and outbuildings. Lance says, "Our garden produces as many vegetables as we can possibly eat year-round, a large amount of the seed for replanting, and an increasing amount of our fruit. Our food storage includes some canning—jam, tomatoes, pickles, and salsa—but most foods are stored in the freezer or root cellar. By summer's end, Jennifer has our 8-cubic-foot freezer packed into a nearly solid cube of frozen vegetables and fruit! The more water we are able to pump, the more food we are able to grow, and the less dependent we are on oil-intensive agriculture, shipping, and food storage."

SUNSHINE IS SUFFICIENT

Since most off-grid folks do not have enough RE generation capacity to get them through sunless or windless periods, living with an engine generator has more often than not become a fact of life. But it doesn't *have* to be that way. When asked about renewable energy droughts, Lance responds, "It's back to that question that folks always ask us, 'What happens when you run out of electricity?' Well, we don't run out of electricity—we never have! I reset the battery monitor when I installed the new set of Concorde AGM batteries four years ago, and the cumulative data shows they've never been drawn below 75 percent of full charge. So our hands-on, base-load-plus-discretionary-load management system works well.

"In more than 25 years now, we have never had an unplanned outage," says Lance. "I have shut down the system for work and maintenance, but it never—and I do mean *never*—has just gone out. By accepting that we have limitations, we build reliability into our systems." A reliable system, and a lifestyle focused on sustainability, self-reliance, and independence, is exactly what Lance and Jennifer have built.

ACCESS

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Lance & Jennifer Barker, 15013 Geary Crk. Rd., Canyon City, OR 97820 • 541-542-2525 • jbarker@highdesertnet.com • www.highdesertnet.com/morninghill

SolWest Fair • 541-575-3633 • www.solwest.org • RE educational event

PV System & Homestead Gear:

Apollo Solar • 203-790-6400 • www.apollo-solar.net • Charge controllers

Bogart Engineering • 831-338-0616 • www.bogartengineering.com • TriMetric battery monitor

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Courtesy Forest Stewardship Council

Above: A healthy second-growth forest. Below: A recent clear-cut.

Forest-Friendly Lumber

for Greener Building

by Erin Moore Bean

Do you know how much wood is in your home? According to the National Association of Home Builders, the amount of framing lumber in an average (2,085 ft^2) home is equivalent to a 15,000-foot-long 2 by 4. That's long enough to stretch from sea level to the height of Mt. Rainier. Add in the sheathing, trusses, doors, trim, and cabinetry, and you'll realize the majority of your home grew from trees.

Then imagine following a 2 by 4 back beyond the lumberyard, before the sawmill, to when it was a tree. Perhaps that stick of lumber came from a tree felled in a swath of clear-cutting that left the forest's floor vulnerable to erosion, and its streams' fish-spawning beds full of silt. Perhaps it grew on the traditional land of a native tribe, and was logged without consent or consideration for cultural value.

Our appetite for wood has effects beyond felled woodlands—forests from the tropics to the far latitudes transform the greenhouse gas carbon dioxide (CO_2) into oxygen (through photosynthesis), and they are rapidly disappearing. "We've lost well over 80 percent, globally, of the earth's original forest," says Brant Olson, old-growth campaign director for the Rainforest Action Network. "The 20 percent that remains is largely in fragmented habitats." Only five percent of the United States' original old-growth forests remain intact, says Olson.

When building your home, you could avoid these issues by selectively harvesting the wood yourself from your property, but for most, that's not an option. There are alternatives to wood, like steel or composite materials, but these options carry different environmental costs. Lumber is a renewable resource—as long as the forest is managed correctly.

Certifying Wood

Several groups provide third-party certification for wood products, and rigorous standards have been established to ensure that their timber is grown equitably and sustainably, protecting forests and consumers.

Forest Stewardship Council is an international organization that brings people together to find solutions to the problems created by bad forestry practices and to reward good forest management.

The nonprofit Forest Stewardship Council (FSC) is the global accreditation organization for green forest certification, and it's supported by major environmental organizations worldwide. Forest managers voluntarily meet the FSC's standards and agree to a five-year contract. An FSC representative audits the certified forest at least once a year, to be sure the agreement is being upheld.

Opposite and right: www.mattemrichphoto.com

Left: A logger cuts into an old-growth Douglas fir. Clear-cutting practices and their negative impacts on plant and animal life, as well as stream health, have remained controversial, especially in the Pacific Northwest.

Below: The FSC-certified stamp is an assurance that the lumber you're buying comes from sustainably managed forests.

Courtesy Forest Stewardship Council

There are three main areas of concern for certification; the first being ecological impact. The manager of a certified forest must create management plans following FSC standards for controlling erosion, minimizing forest damage during harvesting and road construction, and protecting the forest's water quality. The FSC prohibits use of pesticides that may accumulate in the food chain, and requires forest managers to promote non-chemical methods of pest management. Genetically modified organisms of any kind are not allowed, and exotic species are only permitted if they are carefully controlled and actively monitored.

The FSC requires sustainable harvesting practices. Rather than clear-cutting across entire swaths of land, forest managers generally use "selective harvesting," which removes some trees but leaves some older specimens for reseeding. Whereas industrial clear-cutting inhibits biodiversity and leaves forest soil prone to erosion and flooding, selective harvesting leaves the forest looking and functioning like a forest should.

FSC certification also includes standards to protect indigenous rights. If a group has legal or customary rights to the land, their control must be respected. If there are substantial disputes about ownership of the land, the FSC will not certify its wood. Any sites within the forest that are of special cultural significance must be recognized and protected by forest managers.

Finally, FSC certification requires that forest management activities enhance the economic well-being of forest workers and local communities. Managers are required to meet or exceed laws regarding the health and safety of workers, and the workers must be allowed to organize and voluntarily negotiate with employers. The FSC emphasizes that forests

Courtesy Georgia–Pacific

Because they use wood from small trees or lower-grade species, instead of from old-growth forests, many engineered wood products are considered "forest friendly."

Jonathan Clark/istockphoto.com

New Douglas fir seedlings are planted for future harvesting at this tree farm.

Binders in Engineered Wood

Composite wood products are uniform and reduce waste, but they're not problem-free. Every engineered wood product uses adhesive to bind together its wood particles, and these binding agents can off-gas (emit) toxins into your home. Phenol formaldehyde (PF) is a probable carcinogen found in the majority of engineered wood products. Luckily, off-gassing will decrease over time, especially in well-ventilated areas, but it's a good idea to allow these products to "air out" before you occupy your new home.

Be alert for products that contain urea formaldehyde (UF), which off-gases at a higher rate than its cousin PF. UF is found in many pressed wood products made for indoor use, like particleboard or medium-density fiberboard. To avoid this more noxious binder, use exterior-grade plywood, even indoors, because it typically will contain the more benign PF.

Formaldehyde-free options are becoming available. PMDI is a waterproof, polyurethane-type binder that's moving into the marketplace. Although it's an attractive option in terms of off-gassing, the adhesive is quite toxic until it cures, posing a threat to factory workers' health.

must be economically sustainable as well as ecologically sustainable over the long term, so managers are discouraged from depending on a single forest product or from overharvesting at the expense of future yields.

FSC-certified wood is stamped with their green logo, and is available for purchase at many big-box home improvement stores and local lumberyards alike. Thanks to the Leadership in Energy and Environmental Design (LEED) program, which sets standardized goals for green architecture, builders frequently request certified products, which has helped increase availability nationwide.

As with all labels, you'll need to read the fine print to glean the details of the wood's origin, especially when choosing composite products. Woods from 100 percent FSC-certified sources will be marked "100 percent from well-managed forests." If a product is not entirely from well-managed forests, its label will identify it as containing wood from controlled sources, which meet a less stringent set of standards, but "exclude illegally harvested lumber, forests where conservation values are threatened, genetically modified organisms, violation of people's civil and traditional rights, and wood from forests harvested for the purpose of converting the land to plantations or other nonforest use."

Engineered Lumber

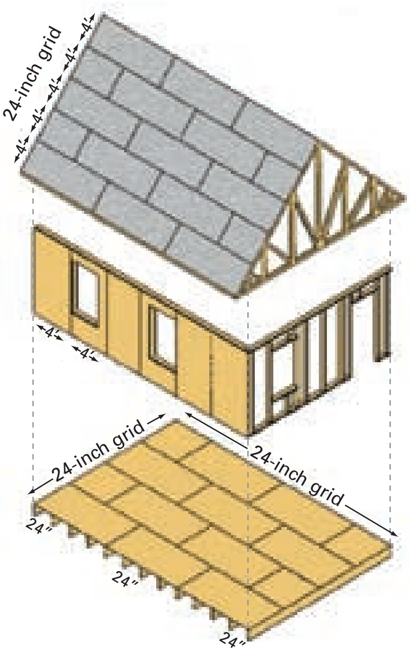
Anyone who's sorted through a stack of 2 by 4s knows that dimensional lumber can be knotty and not always straight, with some pieces being downright unusable. Engineered products are more precise, and manufactured by binding wood fibers, particles, or veneers with adhesives. They are "forest friendly" because they use wood from relatively small trees or from low-grade species such as aspen or soft maple, reducing demand for harvesting larger trees from mature forests.

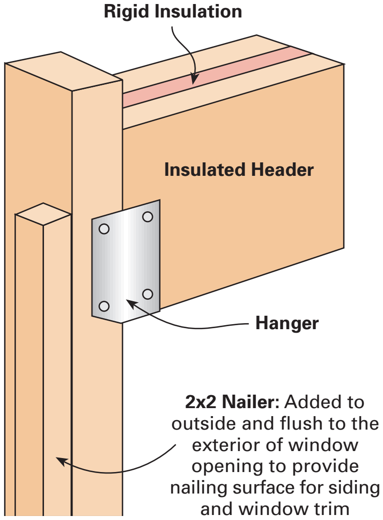
Efficient Building Techniques

Optimum value engineering (OVE) strategies can help reduce your wood use in building projects. The most obvious strategy is to think small. The smaller and simpler your building's design, the fewer materials you'll consume in construction. Keep in mind that some dimensions are better than others—24 inches is the magic number in OVE. For example, most sheet goods come in dimensions with multiples of 2 feet, so planning a building's length, width, and roof pitch for 2-foot increments will reduce wood waste.

The magic number applies to framing as well. In many cases, you can increase your stud spacing from 16 to 24 inches on center. If you're building a two-story structure, and you're framing with 2 by 6s, you can use 24-inch spacing throughout the home.

If your wall studs are spaced 24 inches, you can save more wood by aligning roof trusses and floor beams with the wall studs to distribute weight evenly throughout the structure, and eliminate the need for double top plates.





Your home's corners are another easy place to save on dimensional lumber. Conventionally framed corners use the three-stud method: three studs nailed together with a perpendicular fourth stud for attaching drywall. This creates beefy corners, but it's also wood-intensive and susceptible to thermal bridging (allowing heat to conduct through the studs). A less lumber-intensive method for corner framing uses just two studs and drywall clips, which screw into the interior stud and support drywall without extra wood. This method provides increased insulation space and minimizes thermal bridging.

Consult local building officials early in your design process to make sure OVE techniques are allowed in your area—some localities mandate other building techniques to withstand high winds or potential seismic events.

The most familiar composite woods are sheet products such as particleboard, plywood, and oriented strand board (OSB). Engineered replacements for dimensional lumber are also available. Laminated veneer lumber (LVL), composed of multiple layers of thin veneers bonded together, is often used for beams or headers. I-joists, which are composed of two flanges supported by composite webbing, make for straight, reliable floor joists and rafters.

But engineered products may contain wood from poorly managed forests. Clear-cutting a stand of aspens for particleboard is just as harmful as felling a swath of white pine—perhaps even more so, because aspen forests would naturally transform into more diverse ecosystems with higher-value trees. As with dimensional lumber, you can buy engineered products that are FSC-certified, with the percentage of certified content stamped onto the product.

Beyond Certification

Certification is just one piece of the sustainability puzzle. Although these products are grown in more sustainably managed forests, they may also travel to your door from the other side of the country or even from across the ocean, increasing embodied energy—the amount of energy used to grow, harvest, mill, and then ship the product to you. If embodied energy is a concern, you might choose to buy from a local sawmill—but unless the wood comes from an FSC-certified forest, you can't be sure of the circumstances surrounding its origin.

Engineered wood products carry additional embodied energy. Besides the energy used to grow, harvest, and ship the timber, these products require heat and more machining in their manufacture.

Vote With Your Wallet

While engineered and certified woods both take pressure off the world's forests, and locally milled lumber has low embodied energy, a truly sustainable forest product would combine the best of all worlds.

The optimal way to make sure sustainable lumber is available is to create a demand for it by using your money to vote for sustainable choices. As more consumers decide to make sustainability a priority, the closer we'll get to the goal of a world of truly good wood.

Access

Erin Moore Bean • erinmoorebean@gmail.com

Forest Stewardship Council U.S. • 202-342-0413 • www.fscus.org

Rainforest Action Network • 415-398-4404 • www.ran.org

Advanced framing techniques • www.eere.energy.gov/consumer/your_home/designing_remodeling/index.cfm/mytopic=10090

SUN-CHARGED Transportation

by Donald Dunklee

Auto manufacturers are like many of our grandfathers—set in their ways. Historically, these manufacturers have shown little if any interest in moving our country away from an ever-increasing dependence on oil. Oil is a finite resource, and $5.00 a gallon gasoline will likely be in our not-so-distant future. Knowing this, and having experience with solar energy, led me to build an affordable, solar-charged electric scooter for my daily 5-mile commute to and from work.

This article can help you use solar electricity to charge your own electric scooter. With no tailpipe or power plant emissions, this PV conversion gives you a truly pollution-free ride. With a fully charged battery, the scooter I modified can travel 25 to 35 miles. The PV array recharges the battery pack while I am at work, so I'm ready for the trip home, and back to work the next day. The conversion cost about $1,300 in parts and labor, and required a moderate level of mechanical capability to install, so make sure you have the skills and tools to take this on. These methods may be adaptable to other scooters, but first and foremost, always consider riding safety.

Design Decisions

The bike and solar-charging system are self-contained, and the AC factory charger can be used for a backup charging source during cloudy weather. Modifications had to fit within the weight capacities of the bike, and be safe as well as functional. The PV array needed to fold to not obscure signal lights or get in the way of seating, and protect the glass faces from road hazards. When folded out, the modules cannot be shaded by the bike and must be at an appropriate tilt angle for optimal charging. Finally, all of the parts I used are readily obtainable at local hardware and building supply stores.

The electric scooter I chose was a stock EVT 4000E, still available from various dealers in the United States. Mine was a great deal at $1,999, but prices may be going up. It has a top speed of 30 mph, and a capacity of 330 pounds. It operates at 48 volts from four sealed, 50 amp-hour, 12-volt batteries, and has a rear-wheel hub motor. It has disc brakes on the front and rear, and the motor controller claims a 90 percent or greater efficiency. The lighting and horn run at 12 volts via a 48-volt to 12-volt DC-to-DC converter.

The PV system includes a Xantrex C-40 charge controller, and four Atlantic Solar 12-volt, 30-watt, 16- by 25-inch PV modules. I did not size the PV system based on charging needs, but rather chose the largest PV modules that could be integrated into the design, not cover the tail light or turn signals, and still allow me to carry a passenger.

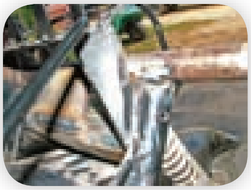
Constructing the Array Frame

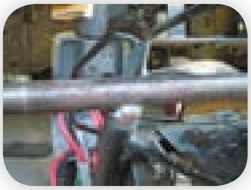
My first attempt at bolting the array to the bike frame resulted in snapped bolts from my bumpy driveway. So I decided to make the mounts much beefier than the bike frame itself, and then add crossover supports for insurance.

Constructing the solar array frame required removing the scooter's body panels to get to its frame beneath. A hole for the main pipe support needs to be cut in each side-body panel. Remove one side at a time so the holes can be located as precisely as possible. Once the first panel was removed, I slid an 18-inch-long 3/4-inch pipe, with a felt-tipped marker centered inside, through the frame to mark the hole on the inside of the other body panel still in place. I repeated the process to mark the second panel. The holes were started with a 1-inch spade bit and enlarged with a cone-shaped rotary grinder. A large round file was used to smooth any rough edges.

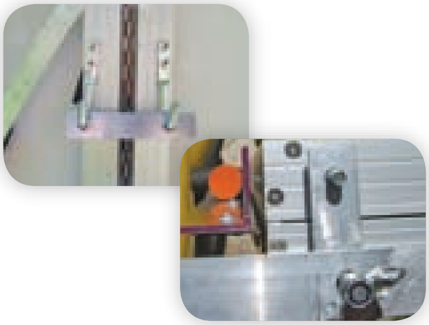
You'll likely need an experienced fabricator to help you with welding an 18-inch length of 3/4-inch black iron pipe, along with reinforcing gussets, to support the 35-pound module assembly. Be sure to remove the scooter's batteries before welding. Painted metal was scraped clean at the welding points to ensure a strong weld. A 2 1/2- by 4-inch piece of 1/4-inch flat stock was welded to the bike frame cross bar to strengthen the connection.

Two 3/4-inch elbows and two 18-inch-long pieces of black pipe complete the array frame mount. Use heavy-duty thread-lock to prevent the pipe elbows from loosening under the vibration and shock of the road. Hand-tighten the vertical pipes and then tighten the elbows so they will support the array frame at an appropriate tilt angle for solar charging, while keeping the PV modules out of the way of the turn signals. Another option to prevent the pipes from loosening is to drill through the threaded fittings once the proper angle is set, and insert a bolt with lock nut.





Deploying the PV Array



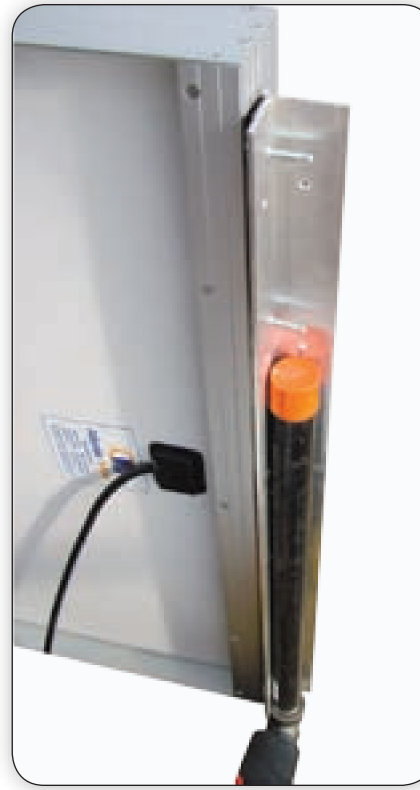
Assembling the Array

I attached 1 1/2-inch aluminum angle with #8 sheet-metal screws to the pipes to make a flat mount for piano hinges, which attach to the module pairs and allow them to fold in. Make sure the two vertical mounting surfaces are parallel to the length of the scooter.

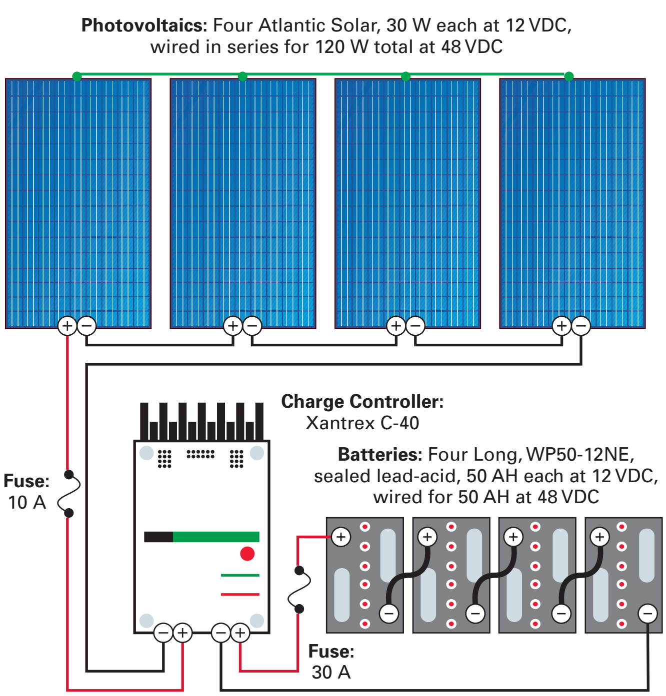
These 24-inch-long, stainless steel piano hinges are secured with #8 screws to each pair of PV modules and attach the pairs to the frame mount. Be careful not to damage the EVA backing on the modules when you're attaching the hinges. Mount the hinges so the modules fold inward, protecting their glass faces from road hazards. When folded, the left and right inboard modules are reinforced with crosspieces of aluminum stock to secure the weight of the array. A piece of angle stock bridges the top of these two innermost modules for additional strength.

With the modules mounted, make the crossover/locking mechanism to support the modules in both driving and charging positions. The crossover creates a triangular joint between both sets of modules, which keeps them from moving while the scooter is moving. These same pieces help support the modules in the open position, even under moderate wind loading. A swivel point made with a bolt and bushing (to limit wear on the aluminum) was placed on the outer top of the inboard module, and a matching bolt without a bushing was placed on the inboard side of the inboard modules. This gives locking points for both the open and closed positions of the array.

A short piece of aluminum tubing slides over the flat stock, locking the assembly into the charging position. This setup has performed well in gusty conditions between 20 and 30 mph. Initially, I had some concern about stability with the array deployed on windy days, but the equal weight distribution out on the two sides and the low center of gravity of the batteries has proven to be a stable combination.



Solar Scooter PV System



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

Getting Wired

Once the frame and modules are in place, and the body parts reinstalled, you can move on to wiring the PVs to the batteries via the charge controller, which is used to prevent overcharging.

On the right side of the bike are main connectors that can be pulled apart, disconnecting the bike motor and wiring from the batteries. There are similar connectors on each battery, so make sure to open all the power connectors before working on the battery leads.

My charge controller is mounted in the scooter's trunk for protection from the environment, but small, weatherproof controllers also are available. To route input wires from the PV array to the controller, drill two 3/8-inch holes in the back cover with the EVT logo, located just behind the driver's seat. Then drill two matching holes in the bottom of the trunk for the controller's output wiring. A nice addition would be to place grommets on the holes to further protect the wiring insulation from abrasion. The output wires from the charge controller are spliced to the main 48-volt cables from the battery, just in front of the brake-light assembly under this cover.

I mounted the charge controller sideways and with the cooling fins on the left, near the hinged front of the trunk, so the rest of the trunk can be used for storage. Attach the negative battery lead to a negative terminal of the C-40. Attach a 30-amp fuse assembly to the controller's battery positive terminal, connecting the other end of the fused lead to the positive lead from the battery.

With the PV modules in the charging position, wire each pair in series for 24 volts nominal. Use a voltmeter to keep the positive and negative wires in the correct polarity. When wired correctly, the two modules should read about 44 volts DC, open-circuit. Use cable ties to secure the wires in place on the array frames.

Drill 3/8-inch holes in the bottom left and right sides of the trunk, feeding the wire from each set of modules through the holes. Check the polarity of each side and make the final series connection. The combined open-circuit voltage should now be about 88 volts DC. Attach a 10-amp fuse assembly to the "PV" terminal of the C-40 and attach the array positive wire to that. Connect the negative array wire to the other negative terminal inside the C-40. This method still allows the factory AC charger to be used, if needed.

Once the array wiring is complete, carefully reconnect all the battery leads in their proper places, and double-check to make sure all bolts, screws, wires, and other parts are properly connected and tightened.

Solar, On the Go

I started this project in early February '05 in a warm solar greenhouse. Putting in two to four hours a week, and despite the minor setback when my first bolt-on design failed, the project was completed by the beginning of April.

The climate where I live in Michigan only allows me to drive the scooter for about seven months of the year, but using it for my short commute to work instead of my 16-mpg Jeep Cherokee saves almost a gallon of gasoline per day. Cost savings on gas, oil, maintenance, and insurance are satisfying; so is the fact that my commute is pollution-free. My scooter is practical too, allowing me to haul moderate loads like the 55-pound bag of buckwheat I carried on the floorboard awhile back.

Compared to gas-fueled engines, electric motors are practically silent. While riding, I can hear everything around me. It is fun to be at a traffic light and talk to the people in the cars that pull up beside me, as well as overhearing kids' excitement about "that really cool motorcycle." Seeing a solar-powered scooter in action shows people that this technology is viable, appropriate, and fun

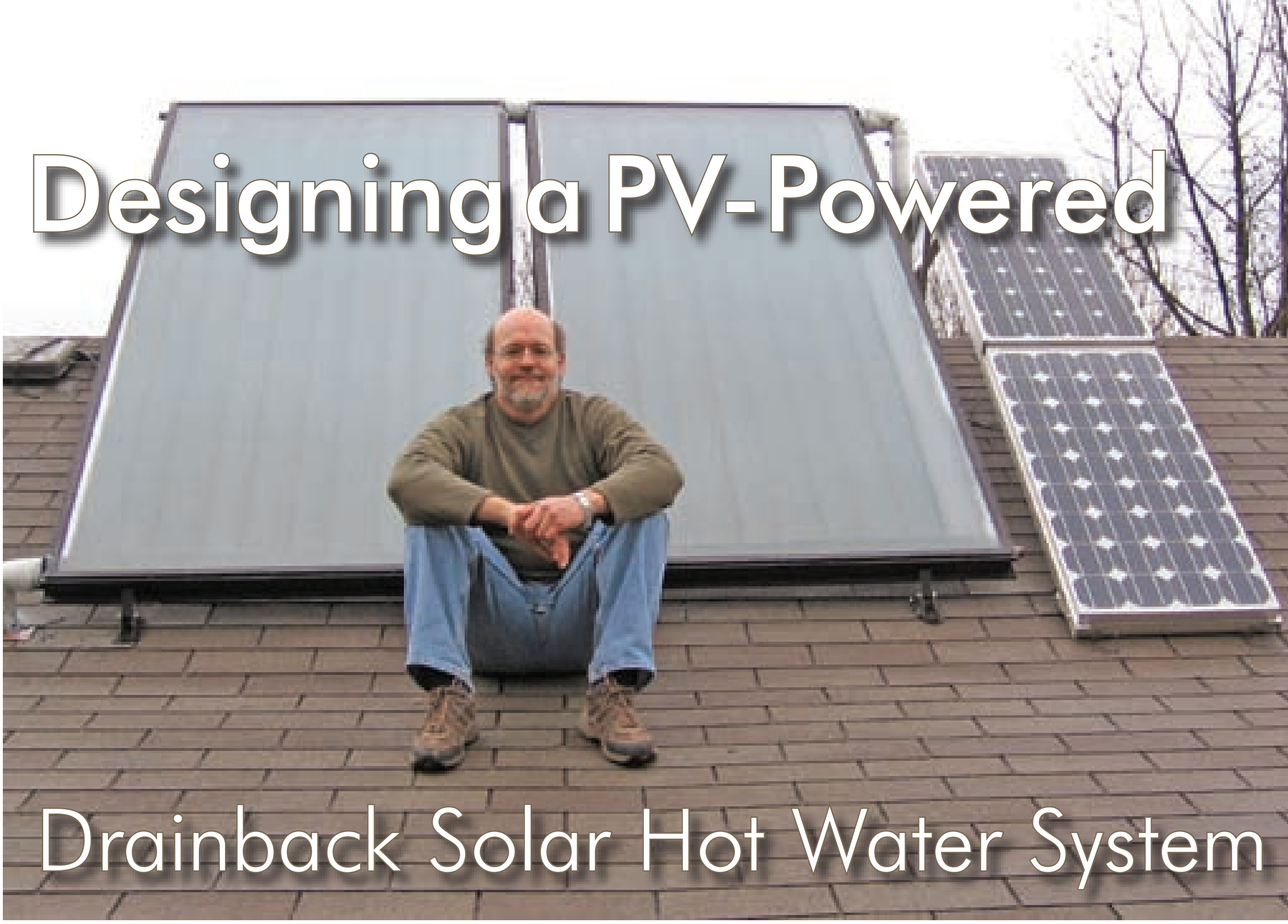
Access:

Donald Dunklee, 11202 E. Carpenter Rd., Davison, MI 48423 • 810-653-1641 • organicgrower@tir.com

Electric Vehicle Systems Inc. • 800-358-8345 • www.evtworld.com • Importer of EVT 4000E; inquire for local dealers

System Components:
Atlantic Solar Products • PV modules (company no longer in business)

Xantrex • www.xantrex.com • Charge controller



Designing a PV-Powered Drainback Solar Hot Water System

by James Dontje

I spend most of my waking hours at work, teaching college students about sustainability and the environment. So, like the plumber with leaky faucets at home, I don't get as many opportunities as I like to make a difference when it comes to my own house. But as someone who is acutely aware of the destructive effects of fossil fuel use and extraction, I feel a great need to walk my talk—especially here in Kentucky, where almost all electricity is generated by coal-burning power plants.

When I heard about the Kentucky Solar Partnership's (KSP) program to provide homeowners with a $500 cash rebate and low-interest loans for solar hot water (SHW) systems, I decided to start planning my own project. Heating water with the sun is one of the most cost-effective ways to use solar energy, and it's a smart financial investment too.

Choosing a System

Although the climate here in Berea, Kentucky, is fairly temperate, winter nighttime temperatures routinely fall below freezing. That ruled out simple batch solar water heaters. It also eliminated open-loop direct systems, which circulate water directly from the collectors to a storage tank, leaving collectors and pipes vulnerable to freezing. A thermosyphon system was out of the question because locating the storage tank above the collectors was not an option at my two-story home.

One solution was a PV-driven, closed-loop system that circulates antifreeze through the solar hot water collectors and uses a heat exchanger to transfer this collected heat to household water. When the sun shines on the PV modules, the DC pump that circulates a propylene glycol solution through the pipes and collectors runs in rough proportion to how much energy the sun can provide—an elegant, grid-free solution. But dealing with the maintenance requirements of periodically checking the pH (acidity–alkalinity scale) of the propylene glycol antifreeze and recharging the system held little appeal for me.

Instead, I considered a closed-loop drainback system that uses demineralized or distilled water as the heat-transfer fluid. In these systems, a pump moves water through the collectors and circulates it through a heat exchanger. When the pump is off, the water drains from the collectors and outdoor piping to a storage tank, assuring freeze protection.

Drainback systems are effective and reliable—some systems can operate twenty years or more without needing service. Their only downside is that larger, higher power AC pumps—requiring more energy—usually have to be used. This is especially true if you're pumping water two stories or more, since the drainback pump has to lift the water to the height of the solar collectors.

In the pressurized loop of a glycol system, all the pump has to do is overcome the friction head of the piping itself.

This isn't the case in a drainback system. When the pump first turns on, it has to move the water from the drainback tank to the top of the collectors to start the flow. This head (vertical lift) requirement is equal to the vertical distance from the water level in the drainback tank to the top of the collectors and is generally much more than the pipe friction head. But once the pipes to and from the collector are full, the amount of pumping energy required is nearly the same as a pressurized glycol system.

The energy penalty required to run the high-head AC pumps needed in drainback systems bothered me. When I described this issue to my wife Laura, she reminded me that using AC pumps would also mean that our solar hot water system—along with the rest of the appliances in our all-electric house—would be inoperable during power outages, which occur occasionally in our semirural location.

Although all the resources I found said that using a PV-driven pump to achieve the vertical lift my system would require just wasn't feasible, I was sure that a little ingenuity, paired with the right pump and a well-located drainback tank, could overcome this challenge.

Picking a PV Pump

I began researching DC pumps for SHW systems, examining their data sheets and performance curves to see which pumps could deliver enough water to meet the flow requirements of the collectors I'd chosen (0.5 to 1.8 gpm per 4- by 8-foot collector), and how much vertical lift they could provide (see Drainback Pumps table).

At the same time, I assessed our two-story house and explored the attic with a tape measure to determine the best location for the drainback tank. It needed to be placed high enough to minimize the head required to pump water to the collectors, and low enough to ensure adequate slope in the piping from the collectors to the tank. To protect it against freezing, the tank also needed to be located in a heated space. The best location in our house for the tank was in the upstairs bathroom, near the ceiling. From my rough measurements, this would require a 10-foot start-up head from the pump, which would be installed in the garage, along with the other balance-of-system components.

A backyard test determined that the PV-powered DC pump could provide adequate vertical lift for the drainback system.

Friends and family helped install the two AET solar collectors.

PV-Powered Drainback Pumps

Pump	Maximum Flow Rate (GPM)*	Maximum Head (Ft.)**
El-Sid 10PV-12V	3.00	3.50
March 809-BR 12V	4.25	7.00
El-Sid 20PV-12V	5.00	7.00
March 809-BR-HS 12V	6.50	15.00
Conergy Suncentric 7323	17.00	10.00

*At no head. **For starting pump.

Wrapping the solar storage tanks and heat exchanger in radiant heat-barrier insulation improves the system's efficiency by slowing heat loss.

All the pumps I compared could provide sufficient flow for the two-collector system I wanted to install. But one pump I considered barely had enough head capacity. Although higher-head models were available, this would cause the flow (and power requirements) to be even more out of line with the system's need. Two other pumps I evaluated lacked the head capacity my system would require, which left the March HS ("high speed") model as the best option.

The pump search was a useful learning exercise in another way. While researching PV-driven water pumps, I stumbled across linear current boosters (LCBs), electronic circuits that better match PV output directly to a motor. LCBs boost the current available to the pump, enabling start-ups even under low sunlight conditions. This translates into earlier pump start-ups and longer run-times.

Over the Hurdles

Although the numbers looked good on paper, skepticism remained that the head requirements would overwhelm the pump's abilities. And to receive the rebate and loan, KSP had to approve my system. I detailed the PV-direct system design and provided additional calculations to account for pipe-friction losses. To assuage their concerns (and mine), I agreed to test the PV pumping capacity before installing the system. If the test results weren't in line with the calculations, or the system didn't perform as expected, I would reconfigure it along more conventional lines, using AC pumps.

I put together a test system in my backyard, placing my two 75-watt PV modules at the same orientation and tilt angle that they would be set on my roof. I connected the modules to the pumps (the second pump serves the heat exchanger-to-storage loop) via the LCB, and connected the pumps to a vertical copper pipe that simulated the head required of the pump. The pipe then dumped the water back into a barrel connected to the pump inlet.

I'm sure my neighbors thought this rocketlike arrangement was a bit odd, especially when I set up my test at 6 a.m. to catch the early morning sun. After a few hours of testing, it became clear that the PV and pumps combination could drive the water to more than the required 10 feet of head. Success!

Integrating the Parts & Pieces

After the pumps had passed their test, it was time to install the system. I chose two 4- by 8-foot AET collectors based on reports of their reliability and long history, and purchased them locally from Sunbelievable Services. A couple of friends helped me mount the collectors on our roof. Because Laura and I are often gone during Kentucky's steamy summers, I set the collectors at a 52-degree angle (our latitude—37.58°N—plus 15 degrees) to maximize winter sunlight collection.

To save money and resources, I plumbed two used tank-style water heaters together. These quality tanks had been replaced long before the end of their useful lives. Now they provide 90 gallons of solar hot water storage, supplying preheated water to my backup electric tank-style water heater.

System Costs

Item	Cost
2 AET MSC-32 collectors, 4 x 8 ft., plus mounts	$1,541
Misc. pipe, insulation, fittings, wire, etc.	1,071
2 PV modules, 75 W ea. (Shell SP75 & BP 275)	500
March 809-BR-HS pump, 12 V	195
Whirlpool water heater, 12 gal.	189
March 809-BR pump, 12 V	175
Hardware for PV mounts	142
Solar Converters linear current booster, 7 A	85
Tempering valve	57
3 Thermometers	53
Sight glass for drainback tank	46
2 Used hot water tanks (50 gal.; 40 gal.)	40
Total	$4,094

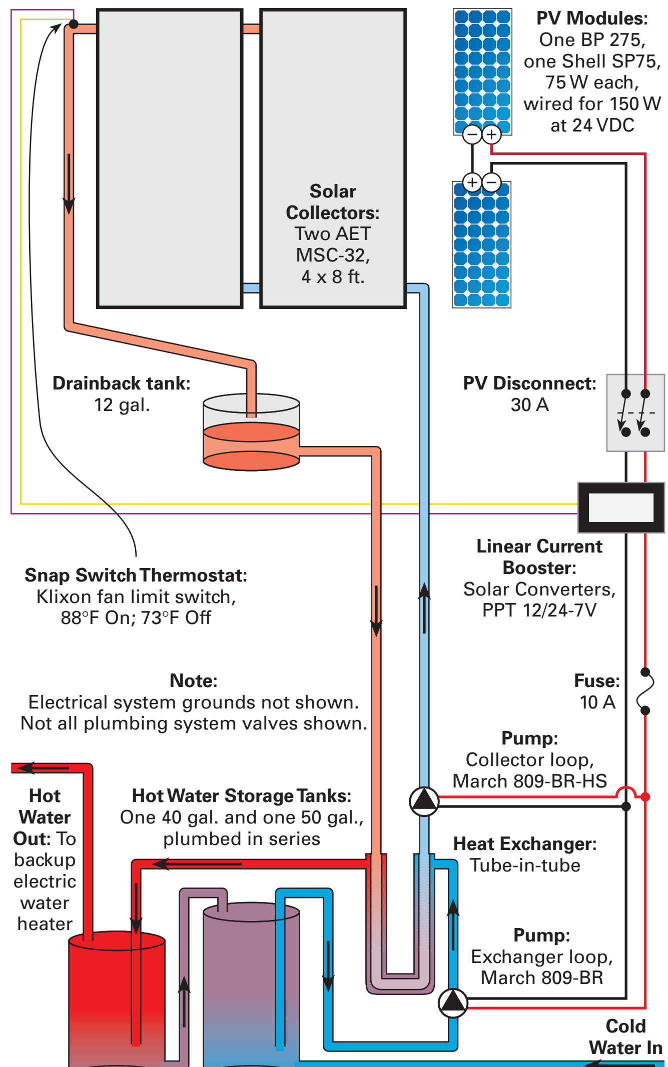
I purchased a 12-gallon water heater from a home improvement store to serve as the drainback tank, and suspended it from the ceiling by threaded rod, bolted through 2 by 4s laid across the ceiling joists. A tank half that size would have been adequate, but I hope someday to expand the system to provide hydronic space heating.

I used Bert Echt's homebrew heat exchanger plans (*HP97*) to create my own "pipe inside a pipe" heat exchanger, running a 3/4-inch copper pipe for the drainback loop inside a 1-inch-diameter copper pipe. The 10-foot run of the heat exchanger is configured in a U-shape to help it fit in the available space.

The PV modules deliver their electricity to the LCB and pumps via a disconnect switch. Following the LCB manufacturer's recommendations, I installed a 10-amp fuse in the pump circuit as additional insurance, in case the internal fuse failed. The thermostatically activated switch (snap switch) connected to the LCB remains open until the temperature of the collector outlet reaches 88°F. It closes at this setpoint and energizes the pump. When the outlet temperature drops to 73°F, the switch opens, deactivating the pump. This causes the circulating fluid to drain back to the tank, preventing it from freezing in the collector or pipes, as well as minimizing the possibility of the pump running too long and actually cooling the water stored in the solar tanks.

One hitch with using a snap-switch as a controller is that the factory setpoints can cause the pumps to cycle in colder weather. If the tanks contain cold water in the morning, they quickly cool the collector water to below 73°F, causing the system to shut down until the collectors warm again. After a few more cycles like this, the drainback water loop stays above 73°F and the pumps stay on. To eliminate the inefficiency of those on–off cycles, I'm considering replacing the switch with a limit switch with a lower threshold or just using a single-point snap switch that will turn off the pumps at temperatures below 40°F. Another option would be to use a DC differential controller available from Art Tec.

Dontje Drainback Solar Hot Water System



Tech Specs

Overview

System type: PV-direct, drainback solar hot water

Location: Berea, Kentucky

Solar resource: 4.5 average annual peak sun-hours

Production: 240 KWH per month (average)

Percentage of hot water produced annually: 82 percent

Equipment

Collectors: Two AET MSC-32, 4 x 8 ft.

Collector installation: Roof-mounted on south-facing roof, 52-degree tilt angle

Heat exchanger: Custom-built

Heat transfer fluid: Distilled water

Circulation pumps: March 809-BR-HS (collector loop); March 809-BR (exchanger loop)

Pump controller: Klixon fan limit switch

Photovoltaic modules: Two: one BP275, one Shell SP75; 75 W STC, wired in series for 150 W at 24 VDC nominal

Linear current booster: Solar Converters, PPT 12/24-7V

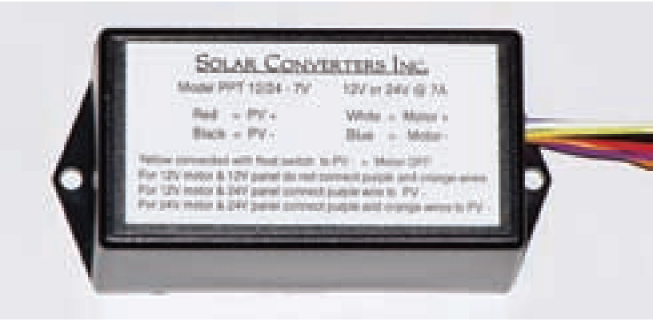
Storage

Solar tanks: Two used; 50 gal. and 40 gal.

Backup water heater: State Select, 47 gal., electric

System performance metering

Thermometer: Three, Honeywell dial (required by KSP for system performance verification)



Courtesy www.solarconverters.com

A linear current booster boosts the current available to the pump, enabling start-up in low sunlight conditions.

To minimize pump head, the drainback tank was mounted near the ceiling in the second-floor bathroom.

Lessons Learned

Retrofitting a drainback system into an existing home can be challenging. In my case, the collectors and plumbing had to be precisely placed to minimize the vertical lift needed, and plumbing sloped enough to achieve good drainback. With copper prices on the rise, the plumbing complexity translated into high balance-of-system costs, and the layout of the storage tanks and heat exchanger in the garage resulted in some extra twists and turns. Because I used PV modules from two different manufacturers, I had to design and build my own aluminum roof mounts, which also added to the system's costs.

Although this system requires more PV capacity than the 10- or 20-watt module used in most PV-direct glycol systems, having two 75 W modules is probably overkill. The rated power of the pumps is about 70 watts, and they run for about 6 hours each day, consuming about 420 watt-hours. Factoring in efficiency losses, with an average daily solar resource of 4.5 sun-hours, the modules typically can produce about 600 watt-hours on a sunny day. One 100 W module would probably have been optimal, but I'd picked up the used modules for a song. I am currently exploring ways to piggyback a charge controller into the circuit to charge a battery with the surplus electricity the modules produce during portions of the year.

Electric Water Heater Energy Consumption

With SHW

With SHW	No. of Days	Total KWH	Avg. Daily KWH
First week	6.13	21.58	3.52
Second week	6.03	19.59	3.25
Third week	5.98	35.04	5.86
Fourth week	6.69	42.11	6.29
		Avg. Daily KWH, with SHW	4.77

Without SHW

Without SHW	No. of Days	Total KWH	Avg. Daily KWH
Mar. 13–14, '03	1.07	9.61	8.98
Nov. 23–27, '05	3.76	35.68	9.49
Nov. 29–Dec. 3, '05	3.76	36.13	9.61
Mar. 15–19, '06	3.76	38.39	10.21
		Avg. Daily KWH, without SHW	9.70

Solar Success & Troubleshooting

On the first sunny morning after I completed the connections, the thermostat switch activated the pumps, which circulated water through the collectors. By late afternoon, the system had heated 90 gallons of water to 120°F—providing ample hot water for our household.

Several measurements I'd taken before the SHW system installation showed that our electric water heater typically used about 9.7 KWH per day. During 24 days of testing after the system installation (most of which were in November, a cloudy month in Kentucky), the backup water heater averaged 4.7 KWH per day—more than a 50 percent reduction in consumption due to the SHW system (see Consumption table).

Coal is king in Kentucky, and electricity is cheap. We pay about $0.06 per KWH, so our savings from the SHW system was about $9 a month during the winter. When sunshine is more abundant, the system should meet almost all our water heating needs, providing an annual savings of about $175. But the payback goes beyond greenbacks. Coal-generated electricity contributes to acid rain and smog formation, and mountaintop removal mining for this finite resource carries its own set of environmental consequences. By using the sun's energy to meet most of our water heating needs we're minimizing our reliance on King Coal and making a difference right at home.

Access

James Dontje • jamesdontje@gmail.com

Kentucky Solar Partnership • www.kysolar.org • SHW incentives

System Components:

Alternate Energy Technologies • 800-874-2190 • www.aetsolar.com • Flat-plate solar collectors

BP Solar • 301-698-4200 • www.bpsolar.com • PV module

March Manufacturing Inc. • 847-729-5300 • www.marchpump.com • DC pump

Solar Converters Inc. • 519-824-5272 • www.solarconverters.com • Linear current booster

SolarWorld AG (purchased Shell Solar) • 800-947-6527 • www.solarworld-usa.com • PV module

Code Changes through the Years

John Wiles
Sponsored by the U.S. Department of Energy

The *National Electrical Code* is the most comprehensive electrical code in the world and the most widely adopted code in the United States. Its use has resulted in generally safe and hazard-free electrical systems in the United States for 110 years. As electrical power systems, photovoltaic installations fell under *NEC* requirements from their very inception, although it wasn't until 1984 that additions to the code specifically addressed this technology.

Making Solar Electricity Safer

In the mid-1970s, Atlantic Richfield Company (Arco) and a few other companies started producing PV modules for use here on Earth. Previous to this, PV technology had been so expensive that NASA was one of the few organizations that could afford it, and they used it primarily to power satellites for communications and space investigations.

Many of the first "terrestrial" PV modules were for off-grid applications used by people in the back-to-the-land movement and for remote agricultural applications. The telecommunications and railroad industries also were early adopters of PV technology. They were interested in getting power to mountaintop repeater stations and remote railroad signals without having to deliver propane to run generators.

When the California rebate programs started in 1998, PV had recently moved onto the grid with the utility-interactive systems. Now, more than 95 percent of the PV systems being installed in the United States are utility-interactive systems. But code changes over these several decades have continued to address both off-grid and on-grid systems.

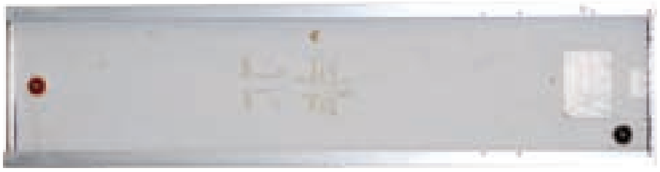
Small Changes, Bigger Results

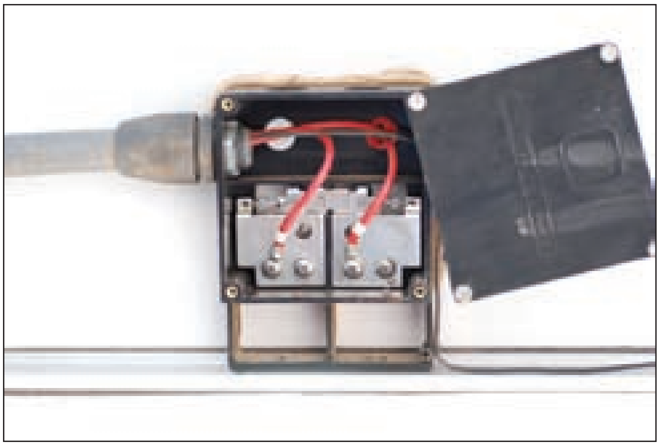
In 1984, Article 690 was added to the *NEC* to deal specifically with PV systems. At that time, PV modules by Arco and others had single terminals for positive and negative outputs on opposite ends of the modules, a configuration that seemed to require single-conductor, exposed cables to be used. The PV industry had successfully argued that it would be a waste of money to run two-conductor jacketed cables or conduit to these widely spaced terminals (despite the fact that copper cables were relatively inexpensive then, compared to today's prices). Section 690.31 in the *1984 NEC* allowed single-conductor exposed cables to be used in PV systems. There are no other sections of the *NEC* that expressly allow exposed conductors operating up to 600 volts in the residential environment. Electrical connections that are easily pulled apart and single, exposed conductors that are readily accessible are viewed as dangerous shock hazards. As the number of installed systems operating at these voltages has greatly increased in recent years, the danger has become more widespread. The *2008 NEC* may begin to place restrictions on using these types of cables with PV.

New connections. In those early years, although the majority of PV installations were off grid, the early PV code requirements in Article 690 were written for utility-interactive systems. In the 1980s, the U.S. Department of Energy, which sponsored code-writing activities, believed that rooftop, building-integrated, utility-interactive PV systems were the future. They were right—but just 25 years early.

Over the years, due to pressure from the *NEC*, the PV industry added junction boxes and covers to limit access to module terminals, and also designed boxes that could accept conduit. Today, the majority of PV modules have factory-attached cables with Multi-Contact connectors at their ends. This easily connected wiring method makes for a time- and cost-saving installation (no conduit/no terminals), but does not necessarily result in a more robust, long-lasting installation. Direct module-to-module connections with cables protected by a raceway, such as conduit, has proved to be a very durable and safe wiring method, not only in PV systems, but in numerous other outdoor electrical systems.

Obsolete: Single exposed (top) and boxed (bottom) terminals at opposite ends of the PV module.





No longer common, but perhaps preferable: Direct wiring in conduit.

The current standard: Multi-Contact (MC) connectors.

Ground-fault, anti-fire devices. In early 1984, while the *1987 Code* was being formulated, two engineers (also journeymen electricians) from Sandia National Laboratories made a presentation to the code-makers at NFPA, showing pictures of a ground-faulted PV system in which a module had caught fire. They failed to mention that the module was an unlisted, early release, thin-film module that was never produced in any great quantities. But already on alert for anything that might pose a fire risk, the NFPA immediately called foul, worrying that electrical fires in residential attics caused by ground-faults in PV systems would be very difficult to extinguish. The PV industry was "directed" to add Section 690.5 in the *1987 NEC* requiring a ground-fault, anti-fire device in PV systems that are mounted on the roofs of dwellings. The *2008 NEC* will take this one step further and require these ground-fault protection devices on *all* PV systems, no matter where they are located. The additional requirement will be added to deal with circulating ground-fault currents that can be larger than expected and that can continue to circulate unless interrupted by the ground-fault device.

Rerouting output conductors. Through the 1980s and '90s, many off-grid PV systems still were not being inspected, nor were many "newfangled" utility-interactive PV systems. Most off-grid PV systems were out of the reach of mainstream inspection organizations, and many of the earliest utility-interactive systems were unpermitted "guerrilla" installations and, therefore, not on inspectors' radars.

From 1984 through 2001, although Section 690.14 in the *NEC* referred installers and inspectors to Article 230 for the location of the PV DC disconnect switch, most PV installers were unfamiliar with that section since it applied to AC service entrance wiring, which they did not typically deal with. The result was that, for rooftop-mounted systems, most installers ran the output conductors from the PV array through the roof at a convenient point near the array, into the attic, and then through the house to a disconnect device in any location that was most convenient. However, these conductors, which are always energized when the PV array is illuminated, pose fire hazards in attics and walls, and shock hazards for the unwary home owner who might drive a nail through them.

Inspectors, who were very familiar with Article 230 of the *NEC*, were unhappy with this unsafe practice, and sent so many complaints to the NFPA that the code writers rewrote Section 690.14 in the *2002 NEC*. This section now requires that PV source and output conductors be routed outside the house until the conductors reach the DC PV disconnect, and that the disconnect be located in a readily accessible location. Three years later, the *2005 NEC* made an allowance for using metal conduit for routing these DC PV conductors through the attic and the house. However, stay tuned—fire departments may have the last word about using these energized conductors inside the house. Even in metal conduit, these always-energized circuits (frequently hidden in walls and insulation) present a potential shock and additional fire hazard as they can be accidentally cut with the power tools used by firefighters putting out a house fire.

Grid-synchronous inverters integral to the module.

AC PV modules. In the *2002 NEC*, a new section was added and several others modified to address the introduction of new AC PV modules. These small "PV systems" consisted of a PV module (or in one case, two modules) with a utility-interactive inverter bonded directly to the back of the module. When connected according to the code requirements to a 120 VAC circuit, they were a relatively inexpensive way to get a small PV system up and running. Although a couple of brands were available, they were limited in production and are no longer available. However, there are some new AC module products that could hit the market soon.

On the horizon. The *2005 NEC* was modified to allow the use of ungrounded PV arrays and transformerless inverters in PV systems. Without a heavy and expensive transformer, these inverters are especially appealing, and have already become popular in Europe.

Through the Ages

An involved and proactive PV industry provides constant improvements and updates for each new edition of the *NEC*, ensuring that definitions are modified and added, and refining, expanding, and even deleting requirements as PV systems and equipment evolve. The result is that PV systems are becoming safer, more durable, and more reliable. And the *NEC* will help guarantee that, over their lifetimes, PV systems will achieve the maximum potential possible toward a renewable energy future for the country.

Other Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me at the location below. See the SWTDI Web site (below) for more detailed articles on these subjects. The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

Access

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The 2005 *National Electrical Code* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA) • 800-344-3555 or 508-895-8300 • www.nfpa.org

PV Progress

by Don Loweburg

Over the last few decades, two main forces have been driving the advancement of the photovoltaic (PV) industry. Technical improvements, such as module efficiency and inverter design, have expanded the market beyond off-grid users. Policy improvements, such as streamlining utility interconnection standards, and the growing availability of financial incentives for grid-tied systems, have made using the technology more economically feasible for a wider variety of applications.

Equipment Evolution

In 1987, a typical PV module produced from 35 to 50 watts (W) and cost about $10 per watt, retail. Module efficiency ranged from 10 to 12 percent. And although output rating tolerance typically fell within the range of plus/minus 10 percent, field-measured values generally fell outside (on the low side) of these limits. Some modules of this vintage also tended to yellow or brown after a few years in the sun, a condition caused by deterioration of the encapsulant used to seal out moisture. A standard module warranty at this time was only ten years. Despite this, many of these early model modules are still generating electricity after more than twenty years of service.

In two decades, the per-rated-watt cost of modules has decreased by half, while the average module size has increased three- to fourfold.

In two decades, the per-rated-watt cost of modules has decreased by half, while the average module size has increased three- to fourfold, falling within the 175 to 200 W range. Module efficiency has also been on the upswing, averaging about 15 percent; one manufacturer (SunPower) reports a module efficiency approaching 17 percent. Typical output tolerance has narrowed to the plus/minus 5 percent range, and at least one manufacturer (Evergreen) holds the lower limit to minus 2 percent. Improved encapsulation means that module discoloration is a problem of the past, and most modules now come with a 25-year warranty. These advances have been the result of constant, incremental improvements in cell and module manufacturing, such as improved antireflective surfaces, more efficient use of silicon, better regulation of the cell manufacturing process, and tighter quality-control measures.

Developments in PV power conversion equipment have also taken place on a parallel track. Twenty years ago, inverters, which convert DC produced by a PV module (or stored in a battery bank) to AC, were in their infancy. Trace Engineering was one of the first companies to offer a 1,500 W inverter and to make higher-efficiency, improved waveform (modified square wave) units intended strictly for off-grid applications. These inverters enabled the operation of many conventional AC appliances, materially improving the ease of off-grid living. These inverters offered efficiencies in the mid-80 percent range and carried two-year warranties.

Off-grid inverter technology today has evolved with improved reliability, waveform quality, and efficiency. Now, off-grid inverters are available that have true sine-wave output (the same as, or often better than, commercial power) and high power capacities. Many modern inverters can hit the 85 to 90 percent average efficiency mark. And stacking options allow multiple inverter configurations for both 120 and 240 VAC applications. Some contemporary battery-based inverters also allow for synchronization with the grid.

Inverters intended for grid connection (without battery backup) also have improved significantly. Early grid-connected inverters typically operated at 48 VDC nominal and had efficiencies in the 80 percent range. Efficiency of modern grid-tie inverters is about 95 percent, due primarily to the use of high-voltage PV inputs. Most grid-tie inverters for residential applications now have onboard output metering, meeting requirements of many programs that provide performance-based incentives. Other improvements include outputs for computer logging and remote monitoring, which allow users to keep tabs on their systems even if they are off-site. Today, most inverter manufacturers back their products with up to a ten-year warranty.

Policy Drives PV

Though a product's technical performance, reliability, and efficiency are important, government incentives and the liberalization of utility interconnection policies have played a vital role in fostering the global surge in PV use.

In 1978, the Public Utility Regulatory Policies Act (PURPA) was enacted to encourage more energy-efficient and environmentally friendly commercial energy production, and independent generators in the United States were finally allowed to interconnect with the grid. PURPA allowed small-scale electricity cogenerators to sell power to the utility to which they were connected, but usually at an "avoided

cost" rate. These cogenerators often used biomass or even hydrocarbon fuel to generate electricity and heat for their own needs, displacing power purchased from the utility. Although dispatching or selling power was generally of secondary importance to many of these producers, PURPA did open the door for independent renewable energy (RE) generation, such as the large-scale wind farms that began interconnecting during the 1980s.

But without targeting a price for renewably generated electricity, PURPA has only played a support role for the installation of grid-tied PV systems, and has not done much to stimulate demand in the United States. In contrast, European electricity feed-in laws that permit the interconnection of renewable electricity sources and specify tariffs—the high price paid per kilowatt-hour (KWH) of electricity generated—have led to the rapid development of RE resources there.

Here in the United States, individual states have been responsible for establishing net metering policies over the years. Net metering allows customers to receive credit for excess KWH produced when solar output exceeds demand. Minnesota was the first state to establish a net metering policy in 1983, and other states have slowly followed suit.

California's net metering law wasn't enacted until 1996, and originally only applied to residential solar-electric systems. But the state's combination of net metering and a strong rebate program, launched in 1998, has made it a PV leader in the United States. The California rebate program has recently been extended to 2017 and modified to provide production incentives (dollars per KWH) for systems 20 KW or greater, while maintaining an up-front rebate for smaller systems.

Although net metering laws and incentives have resulted in an upsurge in the number of PV systems installed in the United States, PV system installation in Europe and Japan (where *national* laws opened the grid to RE generation) has left the United States in third position. In 2006, PV installations in Japan totaled 883 megawatts (MW). Europe added 611 MW and the United States trailed, distantly, at 137 MW.

Big Mama Calls the Shots

A third driver to this story—beyond technological advances and policy changes—is climate change, coupled with the increasing cost of all carbon-based fuels and the energy they provide. This is becoming a fundamental stimulus for RE technologies, as the far-reaching impact of using fossil fuel comes to light, and these nonrenewable resources become more difficult to obtain and increasingly expensive. Clearly, PV will continue to be an important part of the future as we continue to seek innovative, nonpolluting ways to meet our energy demands.

Access

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Nuclear Revolution?

by Michael Welch

It's been 29 years since an order for a nuclear power plant was placed in the United States, and 34 years since the last plant was completed and commissioned. It is difficult to imagine how an apparently stagnant industry has continued to exist without selling and delivering its primary product, nuclear power plants. Without any new plants in development or going online in the United States, how has this industry managed to survive for almost three decades?

There is a contingency of individuals who zealously believe in nuclear-made energy, and who perpetuate their dream in the public mind. They range from naval-trained nuclear submarine technicians, to physicists and engineers employed by the nuclear industry, to the common person who puts their faith in the worn promise that any technical obstacle to safe nuclear energy can be overcome.

But by themselves, these supporters are not enough to keep the industry alive. The U.S. government makes huge amounts of subsidies available to the industry, keeping nuclear power plant research profitable. In turn, some of those profits are invested in public relations campaigns designed to bolster faith in nuclear energy—keeping the cash cow intact.

The nuclear industry has a long history of relying on public relations campaigns, starting with the Atoms for Peace program in the early 1950s. The idea of this effort was to quell public terror of nuclear weapons by providing a distraction—the unfounded promise of cheap and safe nuclear power for electrical generation. (And not only electricity—I recall my dad talking about plans to use nuclear explosives for construction excavations.) Not only did this campaign kick off the nuclear electricity industry, it set the stage for the next half-century of propaganda from the industry. The industry has an uncanny ability to seize upon every opportunity to promote itself, most recently claiming to be the best answer to global warming. And these campaigns pay off with public poll results swinging back toward nukes with each effort, and ultimately with huge government subsidies.

The Energy Policy Act of 2005 provided more than $13 billion in tax breaks and subsidies to the nuclear industry. And the Bush Administration plans on spending an additional $80 million this year and has requested $405 million for next year on a proposal to reprocess nuclear reactor waste into new nuclear reactor fuel and into bomb-making materials. Without selling even a single new plant in the United States, and with relatively measly investments in public relations, nuclear companies are still making enough money to make it worthwhile to keep trying—and nearly every penny comes from taxpayers.

Time & Cost Overruns

Without government assistance, nuclear energy would be dead. According to *The Economics of Nuclear Power,* a May 2007 report prepared for Greenpeace International, financial institutions have not been willing to fund further development of nuclear energy because of the massive amounts of capital required for constructing nuclear plants compared to other technologies. And it's not just the initial estimated cost that is the problem—it is also the time and cost overruns that have historically been part of nuclear energy projects.

Average construction time for the 48 reactors built worldwide between 1965 and 1970 was about five years. More

Nuclear Power's Promise

Electricity too cheap to meter. Ha! This phrase helped launch the unfulfilled nuclear revolution—the first in a long series of lies to the public. If you subtract the subsidies for nuclear power—the biggest of which is the Price-Anderson Act, which limits liability from accidents—nuclear energy is the most expensive electricity source.

Safe, clean, and harmless electricity. Sure, if you don't mind the leftovers—plutonium in our environment that remains deadly for eons. Dr. Helen Caldicott, founder of Physicians for Social Responsibility, said that plutonium "is so toxic that less than one-millionth of a gram, an invisible particle, is a carcinogenic dose. One pound, if uniformly distributed, could hypothetically induce lung cancer in every person on Earth." And just how "safe, clean, and harmless" would the permanently evacuated area be after the next significant nuclear power plant accident? (The Chornobyl explosion contaminated 17,000 square miles.)

Radioactive waste disposal is not a problem. OK, maybe some day they'll find a technological answer that really works. But the industry has been promising us that fix for about 70 years, and a solution still hasn't materialized.

The answer to global warming. Not only is this a physical and economic impossibility (see CO_2 sidebar), but our fossil-fueled transportation is the biggest climate change problem we face. Offering nuclear energy as the solution to climate change is a smoke-and-mirrors tactic that distracts from the real issues at hand—finding safe, renewable energy solutions.

than 30 years later, this figure hasn't improved. Today, the average time required for constructing a nuclear power plant is about seven years.

The report cited U.S. Department of Energy data, which showed that predicted construction costs for 75 of the U.S. reactors currently in operation totaled $45 billion. However, the final costs for their completion came in at $145 billion—more than triple the original cost estimates. What other industry could survive under those kinds of cost overruns?

Industry Uncertainty

For most energy technologies (and similarly, for most other businesses), lessons learned over time make designing and building power plants easier and cheaper. Not so for nuclear energy. Even after 50 years of commercial use—long enough to call the technology "mature"—a lot of uncertainty exists about which nuclear power plant designs and construction methods are best. New designs—funded by taxpayer research and development (R&D) dollars—continue to be rolled out, eliminating the possibility of plant standardization that would allow an economy of scale to curtail overruns. Considering this, it's doubtful that lead times and cost overruns will ever improve much, if at all.

The Greenpeace report also points to this uncertainty: "The European Investment Bank noted that 'very few nuclear power stations have been built in the last few years and thus the cost of recent plants does not seem a good reference to assess future costs. Additionally, any future development of nuclear energy will be based on the new generation of reactors, and the cost of the new generation is uncertain at this stage.'"

Ironically, the point of new-generation reactor designs is to avoid the very uncertainty that introducing new designs may end up causing. The industry wants streamlined design approval, and it wants reactors that are more generic and can be used anywhere with little modification. But first, the designs need to be tried, and then modified, and then newly tried elsewhere, and so on. It seems a vicious cycle, and because of the long learning period, doomed to always having unacceptable lead times and cost overruns.

Revival or Decline?

By claiming to be the best energy technology to combat global warming (see CO_2 sidebar), the nuke industry is working hard to convince the public that it is time to revive nuclear power in the United States. But it would take 1,500 to 2,000 new nuclear power plants replacing other technologies to make a dent in climate change. And if we were able to immediately bump nuclear energy's share of the world electricity supply to 70 percent, we would exhaust the supply of uranium before 2020, according to the nuclear research and watchdog group Nuclear Information and Resource Service (NIRS).

With high costs, impracticable construction, dubious usefulness, dangerous operations, and deadly waste, we have an industry that by all rights should have died long ago. Considering that there are no redeeming reasons for the continued existence of the commercial nuclear power industry, I am left to speculate about why it still breathes: Is it possible that corporate managers in the nuclear energy industry care not whether another nuke plant is constructed in the United States? Maybe they are satisfied with taxpayer money rolling in to keep them in business. Planning—but never building—nuclear power plants is a risk-free undertaking, and no nuclear accidents will result, so it seems like it might be a good managerial choice.

Nuclear energy implementation is in a long-term decline, despite the incredible amounts of money governments hand the industry. While there are 31 nuke plants planned or under construction worldwide, 119 have been shut down so far. Many others are approaching the end of their useful lives and preparing for decommissioning—another big expense, estimated at one-fifth to one-third of a plant's original construction cost. Because of the inherent safety and waste issues, we need to make sure nuclear power stays on the decline. We already know that nuclear power cannot be the answer to climate change, so it is time we stop wasting money on it and instead use those tax dollars to support renewable energy and energy efficiency. It is our choice to make, but we will have to be outspoken and insistent, lest the nuclear industry continue getting its free ride as it has for the last few decades.

Nukes & CO_2

A common claim of the nuclear industry is that nuclear power does not produce carbon dioxide, the major component of human-caused climate change. Strictly speaking, it's true: The heat released as a result of the nuclear reaction converts water to steam—which is run through a turbine and then captured and condensed again—resulting in practically no CO_2 emissions.

But where carbon emissions are concerned, the entire fuel cycle of nuclear energy needs to be considered, as well as a plant's construction and equipment needs, and eventual decommissioning. Uranium has to be mined and then processed into reactor fuel. After it is used, the irradiated fuel (aka nuclear waste) needs to be stored under highly controlled conditions, or reprocessed into more fuel. This fuel mining, processing, and storage is very energy intensive, and most of that energy comes from burning fossil fuel. Further, much of the equipment used in nuclear power plants is so specialized that it cannot be mass-produced, requiring individual, part-by-part machining and assembly, which is also very energy-intensive work.

According to NIRS, "Taken together, the [nuclear] fuel chain greenhouse emissions approach those of natural gas [plants]—and are far higher than emissions from renewable energy sources [and] emissions-free energy efficiency technologies."

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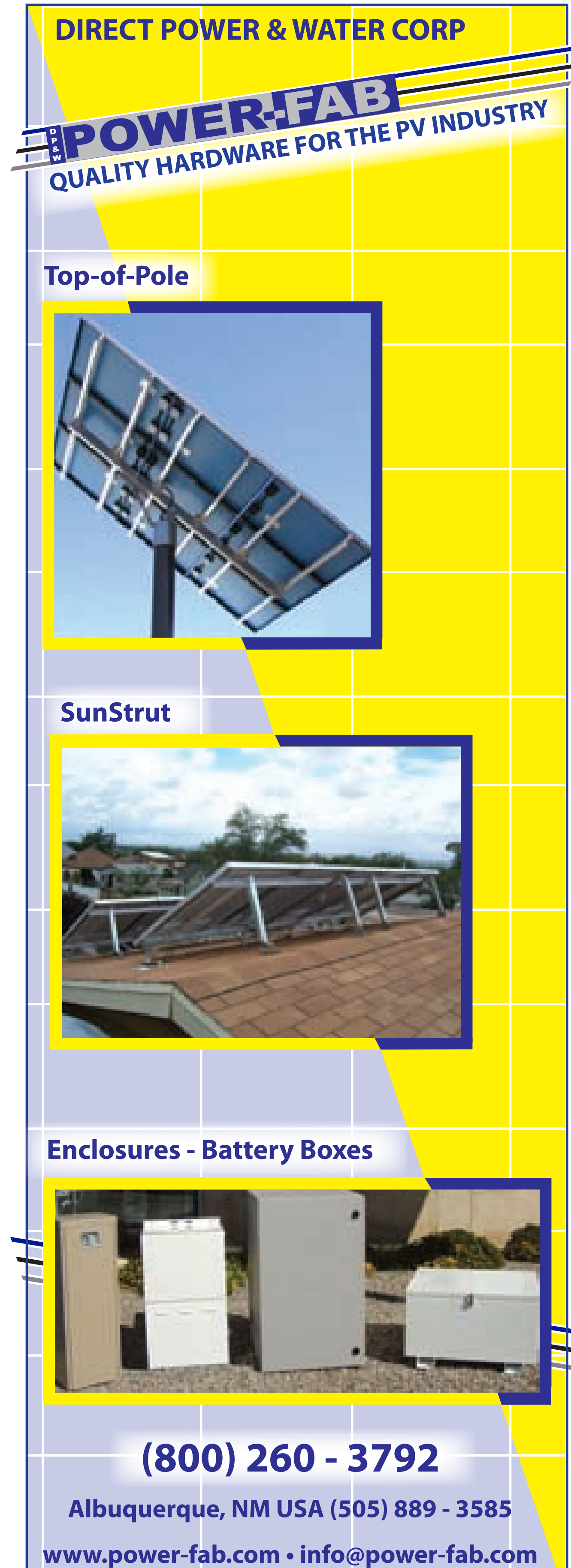
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Therm

Unit of Heat Energy

by Ian Woofenden

Derivation: From Greek therme, *heat, from* thermos, *hot; akin to Latin* formus, *warm, and Sanskrit* gharma, *heat.*

In recent years, because of rising costs for natural gas and electricity, there has been an increased awareness of the importance of efficient space heating and having a tight, well-insulated building envelope. In fact, space heating accounts for more than 30 percent of the energy used in most homes, so this is a prime place to focus our energy efficiency and conservation efforts—and dollars.

In renewable energy (RE) circles, it's much more common to talk about electrical energy than thermal energy. So we're relatively comfortable with volts, watts, and watt-hours as units. But if your big-picture goal is to use RE for *all* your energy needs, learning about thermal units is especially important. Then you'll be able to understand how to measure and use thermal energy wisely, and move toward reducing your reliance on nonrenewable resources to heat your home.

The *therm* is a unit of heat equivalent to 100,000 British thermal units (Btu). It is often used to measure natural gas, a common fuel used to heat American homes. One of two homes in the United States is heated with natural gas—a nonrenewable resource that's becoming increasingly difficult to find, extract, and transport. Prices vary over the seasons and years—the average cost per therm this past winter was $1.50. Because natural gas is used in large volumes for heating, and increasingly for utility-scale electricity generation, it's likely that its cost will continue to rise.

One therm of natural gas contains the energy equivalent of about 29 kilowatt-hours (KWH) of electricity. A typical American home that heats with natural gas uses about 780 therms annually, or a little more than 2 therms per day (58 KWH), averaged over the whole year. Of course, your usage will depend on the size of your home, its thermal efficiency, your thermostat setting, and your climate.

1 Therm
= 100,000 Btu
= 29,000 WH

If you want to get a handle on energy use from heating, take a look at last winter's natural gas bills and make a note of how many therms you used per day. Then set a goal to make changes in your home this summer and fall, so that you can see a decrease in your thermal energy use in the coming heating season. To achieve your goals:

- Contact your local utility and see if they offer home energy audits, or hire an independent energy auditor to help prioritize steps to improve your home's thermal efficiency.
- Make sure your home's envelope is well insulated and tightly sealed against air infiltration. These two measures will usually provide the best bang for your efficiency upgrades buck.
- Replace single-pane windows with more energy efficient, double-pane units, and make sure your windows are caulked and weather-stripped.
- Close the doors to unused rooms to help reduce the area requiring heating.
- Purchase a programmable thermostat, and set it to keep your home at a lower temperature overnight and while you're away. Every degree that you dial back your thermostat can shave about 3 percent off your heating bills.

It's been said that to measure something is to know it. If we want to really understand our thermal energy usage, we need to get familiar with its units. For home heating, many of us need to get familiar with the term *therm.*

Access

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"Efficiency Pays," Bernd Geisler, *HP110*

"The Half Plan: Part One," Gary Reysa, *HP118*

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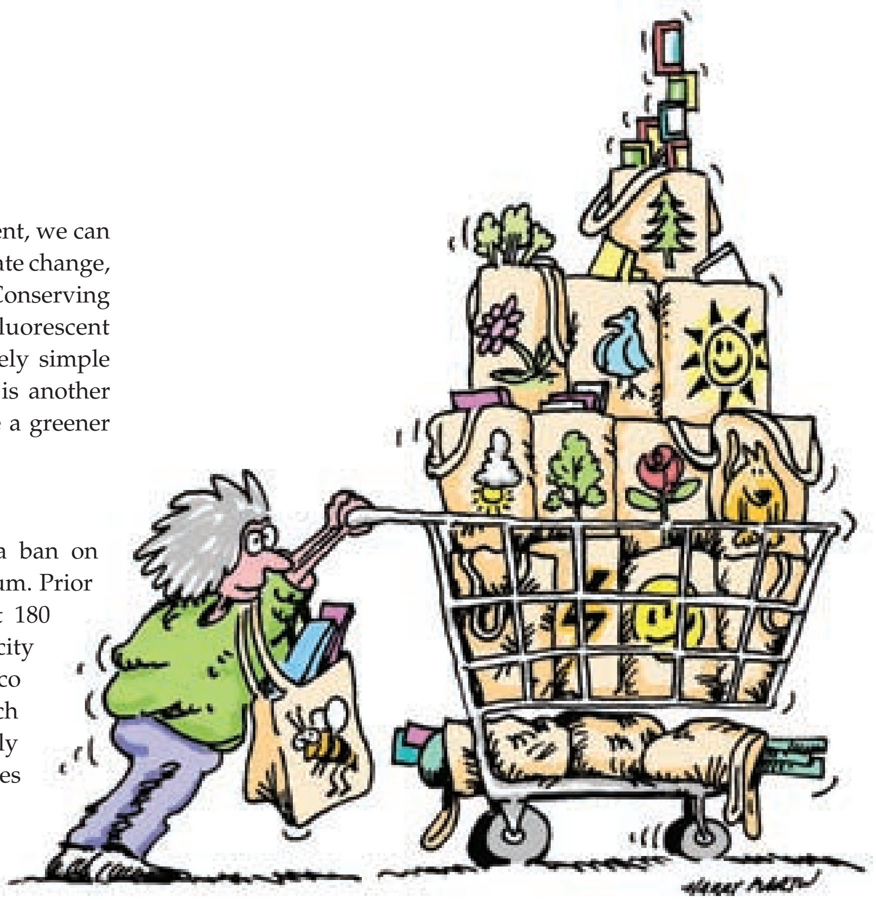
Conservation

It's in the Bag

by Kathleen Jarschke-Schultze



In the face of all the dire news about the environment, we can become overwhelmed. Certainly, in the face of climate change, we all need to reduce our carbon footprint. Conserving electricity is a good way to start. Compact fluorescent lightbulbs and Energy Star appliances are relatively simple ways to save energy. Using cloth shopping bags is another painless way to help save resources and to ensure a greener planet for future generations.

The Problem with Plastic

Recently, San Francisco, my birthplace, passed a ban on plastic grocery bags, which are made with petroleum. Prior to the ban, San Francisco's shoppers used about 180 million plastic bags per year. And that is just one city in the United States! According to the San Francisco Department of the Environment and the Worldwatch Institute, 4 to 5 trillion plastic bags are used annually worldwide. Keeping the world in plastic bags uses more than 40 billion gallons of oil each year. To put this into perspective, the United States consumes 20 million barrels of oil per day. This translates into 23.8 days of oil—just to keep us supplied with plastic bags. If you believe this is not enough to bother about, wait a couple of years.

Besides relying on a nonrenewable resource for their manufacture, bags are difficult and costly to recycle. And whether it's inadvertent or deliberate, plastic-bag litter creates many problems. Once they're tossed, they take about 300 years to photo-degrade. In the meantime, they break into particles that contaminate the soil and watersheds, and enter the food chain when animals digest them. They end up blocking drains and trapping birds, and can kill the livestock and wildlife that accidentally eat them. In the marine environment, plastic-bag litter is lethal, killing thousands of whales, turtles, and other sea life every year. According to Greenpeace, plastic, including bags, is gathered by ocean currents and endlessly circulates in a "trash vortex" that forms in the North Pacific—and can sometimes grow to occupy an area the size of Texas.

Cotton—Collect 'Em, Trade 'Em

I've used cotton shopping bags for several years. I currently have a collection of twelve bags in assorted sizes. The number and size change through attrition and acquisition. So how do I acquire my shopping sacks?

I have small schwag bags—vendor giveaways I've landed from attending electrical or renewable energy conferences. Computer conventions have yielded a couple of freebies. I also buy bags from my favorite grocery stores when they offer a well-made, large variety. These have the store's logo and usually some sort of "green" message on them. When visiting our granddaughter, Clementine, in San Francisco, I scored a Noe Valley Farmers' Market bag. At least two of my bags are from the Midwest Renewable Energy Fair.

I enjoy having so many different bags and am always on the lookout for unique ones to add to my collection. All these different bags get rolled up and put into my own logo bag from my business, Rushing Heart Gardens. I buy blank bags and use our color printer and T-shirt press to make them for family and friends. It is a nice big bag that can hold all the rest.

Bag Lady

I started carrying the bags in my car, usually in the back seat. Then I would forget I had them until I reached the checkout line in the market. "Oh well," I would think. "Next time."

In The Bag— Why Cloth Bags Are Better

- Hold more weight than paper or plastic bags
- Don't tear
- Are washable
- Have fun logos
- In the checkout line, can be conversation-starters about environmental issues
- Save petroleum and wood resources
- Make good sun hats (rolled open halfway); great "emergency" shoe covers to use when you have to change a flat tire stuck in the mud; absorbent wipes for java disasters and other spills en route; in worst-case scenarios, could be used as a compression bandage
- Can be composted when worn out

Then I got a little better—I would remember I'd forgotten my bags as I started down the aisles to shop. Again, I would tell myself there was always next time.

But it was my uber-environmentally aware friend Jennifer Stein-Barker who clued me in to the secret of shopping with cotton bags. She told me you have to take the trouble to go out to the car and get the bags as soon as you remember. She said this would only happen twice. And she was right: The annoyance of having to stop and retrace your steps needlessly is a huge incentive for remembering the first time. Now, I get my bags as I exit the car. I also started carrying them in the front seat for a visual reminder.

Bag It

My twelve shopping bags might seem like a lot, but they serve me well. Whenever I make the journey into town from my remote home, I go with a list. It is usually a long list of various items we need, which involves stopping at a variety of stores. As my trip progresses, the empty bags become full and migrate from the front seat to the back seat. I usually start my shopping in town at the farthest store from my home, and work my way back. Backtracking is wasteful on several levels, but I primarily use this strategy to save gas. However, this method also means that there are times when I have already purchased cold food, and am still several errands—and hours—away from home.

So along with my bags, in the back of my Subaru Baja, I carry one or more ice chests. When I pack my cloth bags with cold and frozen food, I put the frozen items on top if I can. I then place the food, bags and all, into the ice chests, which will keep the food cold until I get home.

Of course, ice cream is the exception. Years ago, I had a bright idea for my husband Bob-O's birthday. I stopped off at the local icehouse and bought a piece of dry ice to put into the bottom of my ice chest. Next, I picked up a lovely personalized ice cream cake. But my plan worked too well. By the time I got home, the cake was completely frozen and solid as a brick. We had to clean up our kindling hatchet and hack the cake into small pieces to eat it.

Baggage

Unfortunately, cloth bags are still an anomaly at most stores. One day, as I stepped up to the checkout in one store I heard the bagger chime mechanically, "Paper or plastic?"

"Neither," I said. "Cotton, please."

He looked at me curiously. "We don't have cotton," he said.

"*She* does," the checker said, as he tossed my bag of bags to the boy. He got a big smile on his face and said, "Cool!"

I've only gotten positive comments about my cloth bags. People will ask me where I get them. I tell them the bags come from all over. Just keep an eye out. More and more stores sell cotton bags with their company logo on them. I try to bring out the right bag for the store I'm in first. I think it encourages the employees to see their store's bags in use. I've found that grocery baggers like my cloth bags—maybe it breaks up the monotony for them.

Some stores will credit you 4 to 5 cents each for bringing your own bag. Although it costs the store only a few cents to provide a bag for you, this does not reflect the true cost—the environmental price to us. So when the checker rings up my purchases and forgets to credit me the refund for using my own bags, I just have them give the refund to the next person in line. I'm hoping that gets the next customer thinking about bringing their own bags.

À la Cart Conservation

Besides inspiring the next shopper to use cloth bags, I make it a point when I start shopping to take a cart from the parking lot into the store. I will wait as someone empties their cart so I can take it. The shopper is always pleased and so life is a little happier. It saves that person from having to leave their open car to look for the cart return or (what I really dislike) just leaving it in the parking space to be in the way for the next guy.

So how about this new etiquette: Conservation in everything except courtesy and generosity. Seems like that would be a refreshing change. We all need to just put one foot in front of the other to keep moving forward on conserving global resources. Even if it is slow or small, take that first step.

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Kathleen Jarschke-Schultze is using her solar clothes dryer every day at her off-grid home in northernmost California.
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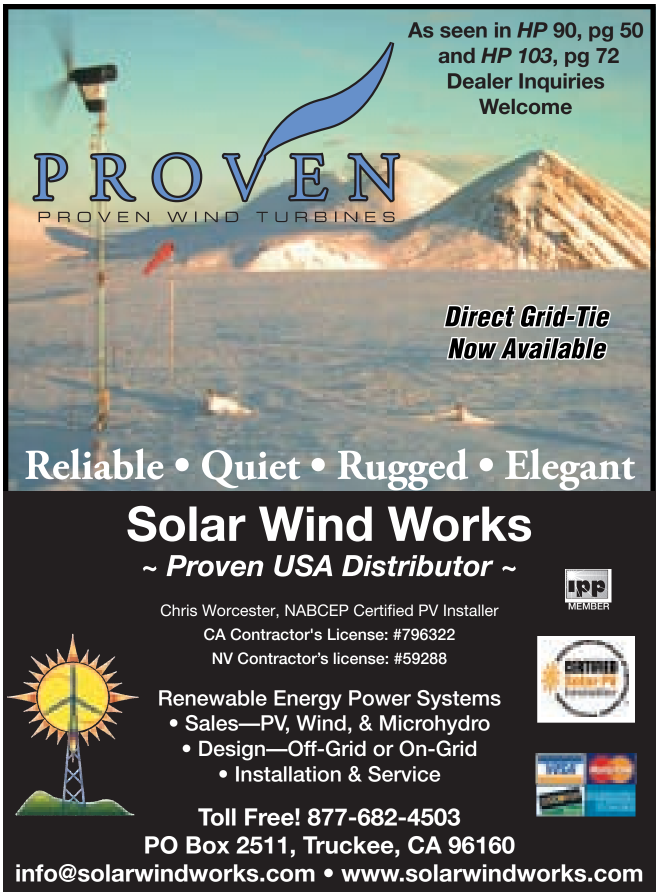
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Oct. 6, '07. National Tour of Solar Homes. Tours in most states. Info: American Solar Energy Society • www.ases.org

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Aug. 4–5, '07. Pomona, CA. So. CA RE Expo. Booths, workshops & demos. Info: 888-647-6527 • www.socalenergyexpo.com

Sep. 24–27, '07. Long Beach, CA. Solar Power 2007. Conference & expo. Info: 202-396-1688 ext. 2 • ebrown@solarelectricpower.org • www.solarpowerconference.com

Arcata, CA. Workshops & presentations on RE & sustainable living. Campus Center for Appropriate Technology, Humboldt State Univ. • 707-826-3551 • ccat@humboldt.edu • www.humboldt.edu/~ccat

Hopland, CA. Workshops on PV, wind, hydro, alternative fuels, green building & more. Solar Living Institute • 707-744-2017 • sli@solarliving.org • www.solarliving.org

COLORADO

Sep. 15–16, '07. Fort Collins, CO. Rocky Mt. Sustainable Living Fair. Speakers, exhibits, vendors, workshops, demos, youth zone, food, music & alternative vehicles. Info: Rocky Mt. Sustainable Living Assoc. • 970-224-3247 • christa@sustainablelivingfair.org • www.sustainablelivingfair.org

Carbondale, CO. Workshops & online courses on PV, water pumping, wind, RE businesses, microhydro, solar domestic hot water, space heating, alternative fuels, straw bale, green building, women's PV courses & more. Solar Energy Intl. (SEI) • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

FLORIDA

Melbourne, FL. Green Campus Group meets monthly to discuss sustainable living, recycling & RE. Info: fleslie@fit.edu • http://my.fit.edu/~fleslie/GreenCampus/greencampus.htm

ILLINOIS

Aug. 11–12, '07. Oregon, IL. Illinois RE Fair, Ogle County Fairgrounds. Info: 815-732-7332 • sonia@essex1.com • www.illinoisrenew.org

IOWA

Sep. 8–9, '07. Solon, IA. I-Renew Energy Expo. Workshops, exhibits, food, entertainment. Info: See following listing.

Iowa City, IA. Iowa RE Assoc. meetings. Info: 319-341-4372 • irenew@irenew.org • www.irenew.org

MASSACHUSETTS

Hudson, MA. Workshops: Intro to PV; Advanced PV; RE Basics; Solar Hot Water & more. Info: The Alternative Energy Store • 877-878-4060 • support@altenergystore.com • http://workshops.altenergystore.com

MICHIGAN

West Branch, MI. Intro to Solar, Wind & Hydro. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com • www.loghavenbbb.com

MISSOURI

Sept. 22–23, '07. Columbia, MO. Ozark Renewable Energy & Sustainable Living Expo. Info: www.ozarkre.org

New Bloomfield, MO. Workshops, energy fairs & other events. Missouri Renewable Energy • 800-228-5284 • info@moreenergy.org • www.moreenergy.org

MONTANA

Whitehall, MT. Seminars, workshops & tours. Straw bale, cordwood, PV & more. Sage Mountain Center • 406-494-9875 • www.sagemountain.org

NEVADA

Sep. 30–Oct. 3, '07. Reno. Geothermal Energy Trade Show. Info: Geothermal Energy Assoc. • 202-454-5261 • www.geo-energy.org

NEW HAMPSHIRE

Rumney, NH. Green building workshops. Info: D Acres • 603-786-2366 • info@dacres.org • www.dacres.org

NEW JERSEY

Sep. '07. Sandy Hook, NJ. Workshops on radiant heating, intertied PV, advanced PV & solar businesses. Info: See SEI listings under Colorado.

NEW MEXICO

Aug. 23–25, '07. Albuquerque. Solar hot water workshop. Theory, design considerations & installation techniques. Info: See SEI listings under Colorado.

Sep. 15–16, '07. Albuquerque. Solar Fiesta. Exhibits & workshops on RE, energy efficiency & sustainable living. Info: See following listing.

Six NMSEA regional chapters meet monthly, with speakers. NM Solar Energy Assoc. • 505-246-0400 • info@nmsea.org • www.nmsea.org

NORTH CAROLINA

Aug. 24–26, '07. Fletcher, NC. So. Energy & Environment Expo. Workshops, presentations, exhibits, clean-air car fair & more. SEEE • 828-696-3877 • info@seeexpo.com • www.seeexpo.com

Boone, NC. Western NC RE Initiative '07 workshops: SDHW; Community-Scale Biodiesel Production; PV & the Code; Solar Space Heating; Small-Scale Wind Installation & more. Info: Appalachian State Univ. • 828-262-2933 • wind@appstate.edu • www.wind.appstate.edu

Saxapahaw, NC. Solar-Powered Home workshop. Solar Village Institute • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OREGON

Sep. 14–16, '07. Portland. NW Solar Expo. Exhibits, workshops & seminars. Info: OR SEIA • 503-821-4340 • www.nwsolarexpo.com

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10-week internships. Aprovecho Research Center • 541-942-8198 • apro@efn.org • www.aprovecho.net

PENNSYLVANIA

Sep. 22–23, '07. Kempton, PA. PA RE & Sustainable Living Festival. Lectures, exhibits, demos & workshops. Info: Mid-Atlantic RE Assoc. • wjhennessy@dejazzd.com • www.paenergyfest.com

Philadelphia Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@verizon.net • www.phillysolar.org/psea.htm

TENNESSEE

Summertown, TN. Workshops on PV, alternative fuels, green building & more. The Farm • 931-964-4474 • ecovillage@thefarm.org • www.thefarm.org

TEXAS

Sep. 28–30, '07. Fredericksburg, TX. RE Roundup. Exhibits, speakers & workshops on RE, efficiency, building, transportation & farming. Info: TX Solar Energy Society • 541-482-0858 • roundup@txses.org • www.renewableenergyroundup.com

El Paso Solar Energy Assoc. Meets 1st Thurs. each month. EPSEA • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group, quarterly meetings. HREG • hreg@txses.org • www.txses.org/hreg

WASHINGTON STATE

Guemes Island, WA. SEI 2007 workshops. Oct. 6: Intro to RE; Oct. 8–13: Solar-Electric Design & Installation; Oct. 15–17: Grid-Tied Solar Electricity; Oct. 19–20: Successful Solar Businesses; Oct. 22–24: Solar Hot Water; Nov. 5–10: Electric Vehicle Conversion. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

WISCONSIN

Custer, WI. MREA '07 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. MREA • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

INTERNATIONAL

AUSTRALIA

Feb. 17–21, '08. Adelaide, S. Australia. Intl. Solar Cities Congress. Support cities in UN energy & climate policies by stimulating interest in RE & energy efficiencies. Info: Plevin & Associates • 61-8-8379-8222 • events@plevin.com.au • www.solarcitiescongress.com.au

COSTA RICA

Jan. 21–27, '08. Rancho Mastatal. RE for the Developing World. Hands-on workshop. Info: See listing for WA State.

FRANCE

St. Laurent de Cerdans. Sep. 3–7: Intro to RE; Sep. 10–14: Solar Electricity Design Course. Info: Les Amis de Numero Neuf • info@lesamis9.org • www.lesamis9.org

ITALY

Sep. 3–7, '07. Milano. European PV Energy Conference & Exhibition. Info: WIP Renewable Energies • 49-89-720-127-35 • pv.conference@wip-munich.de • www.photovoltaic-conference.com

Nov. 11–15, '07. Rome. Wind Expo 2007. International conf. for commerical wind industry. Info: Artenergy • info@windexpo.eu • www.windexpo.com

NEW ZEALAND

Jan. 26–27, '08. Canterbury. Sustainability EXPO. PV, wind, SDHW, energy efficient building design, housing & transport, & other sustainable technologies. Info: Solar Electric Specialists Ltd. • 027-457-6527 • www.sustainabilityexpo.co.nz

WALES

Aberystwyth. RE workshops. Sep. 10–14: PV Installation; Oct. 19–21: Wind & Solar; Oct. 23–24: RE for Planners; Oct. 26–28: Intro to RE. Info: Green Dragon Energy • 49-0-30-486-249-98 • info@greendragonenergy.co.uk • www.greendragonenergy.co.uk

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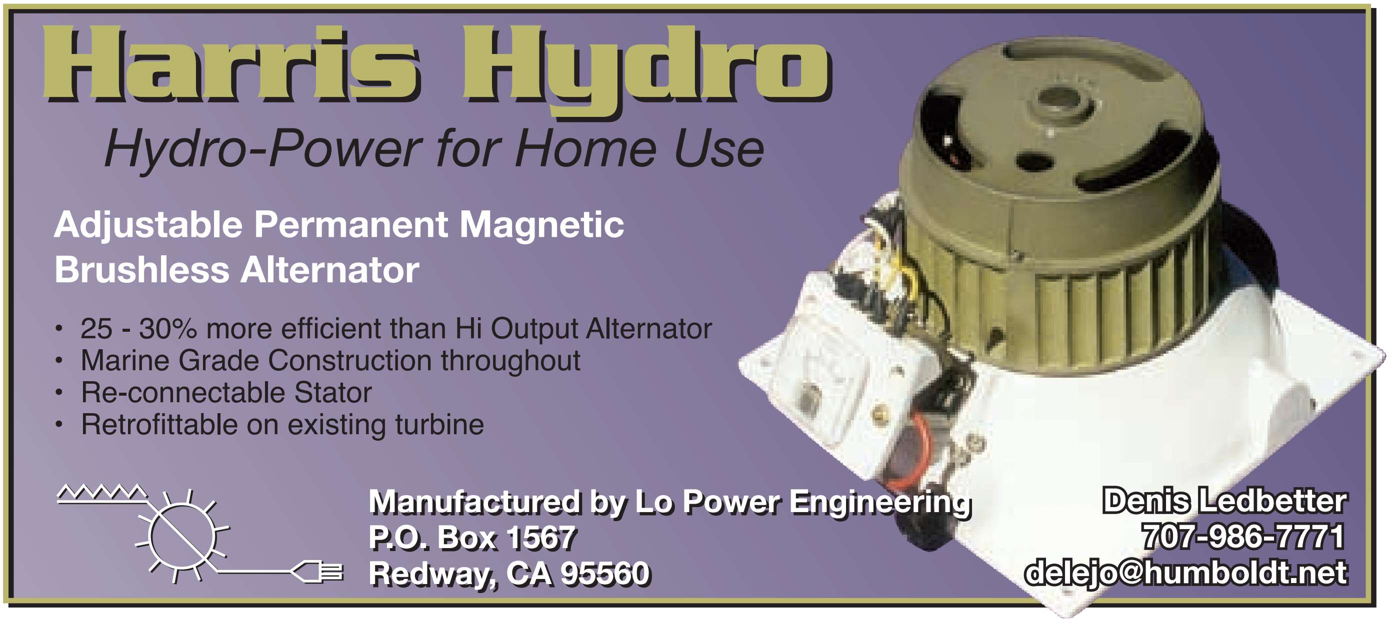
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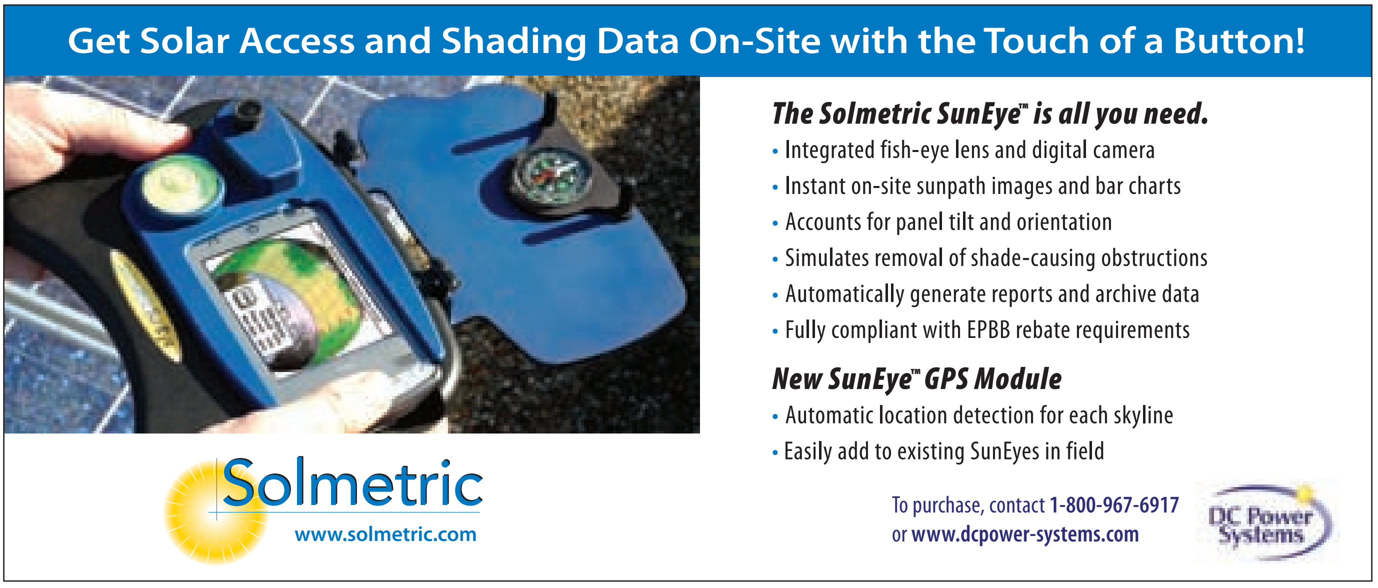
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5/26-27 Microhydro with Don Harris and WNCREI staff at Appalachian State University
6/2 Domestic Solar Water Heating Design & Construction with Fred Stewart at Appalachian State University
6/22-23 Sustainable Community-Scale Biodiesel Production Workshop at Appalachian State University
8/29 PV and the National Electrical Code with John Wiles at Appalachian State University
9/15 Active Solar Hydronic Space Heating with Fred Stewart at Appalachian State University
9/22-23 Small Scale Wind Energy Installation Workshop with Robert Preus of Abundant Renewable Energy at Beech Mountain R&D site
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RE People

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When: 1970 to present
What: Off-grid solar energy systems
Why: Freedom

After living together on their off-grid property for the better part of four decades, *Home Power*'s publishers, Richard and Karen Perez, sum up their homesteading experience: "Vehicle access—hard. Communications—hard. Electricity—easy."

Top: Richard and Karen Perezes' "all-around solar scene." Bottom: Karen and Richard with their two dogs, Shasta and Maggie.

Like a lot of adventure-seeking youth from their generation, Richard and Karen ended up in San Francisco in the late 1960s. Richard came west from Vermont, and Karen left her childhood home in the Saint Bernard Parish in New Orleans. When the San Francisco scene peaked in 1969, Richard and Karen moved north. They landed on Agate Flat in the Siskiyou Mountains of southernmost Oregon, where they picked up 40 acres of extremely remote land—six miles beyond the utility grid—for $7,000 cash. Laughing, Richard says, "The early days were really heroic. We lived in a dome built with hand tools, hauled water in buckets from Skookum Creek, and dealt with kerosene lamps for lighting. Food and building materials were usually packed in on horseback."

Like many off-grid properties, the Perezes' homestead evolved over time. When asked what set him on his path to find a source for electricity, Richard responds, "The Grateful Dead. Period." An old lawn mower engine was rigged up to an alternator, charged a car battery, and just like that, they had electric lights at night and an endless stream of rock and roll.

They installed their first PV module in the early 1980s, and added more modules and new power electronics over the years as finances allowed. Currently, 4,600 watts of PV provide electricity, and six solar hot water collectors provide space and water heating for what Richard describes as "an all-around solar scene."

Richard Perez with Home Power's first Macintosh computer, circa 1987.

Richard and Karen's early experience with solar electricity led them to install systems for their friends and neighbors, and their excitement about renewable technologies led to the creation of *Home Power* magazine in 1987. They saw an emerging technology that was unknown by the people who could really benefit from it, and a burgeoning market with no way to reach its potential customers. From their publishing platform, the Perezes' mission became to "change the way the world makes and uses electricity."

Having inspired a generation of RE users by example and via the magazine, Richard and Karen still have RE dreams of their own. Karen would "love to delete the 'yard bomb' (propane tank) and be able to solar cook all winter." And Richard fantasizes about having an all-electric 4WD pickup that could recharge from their RE system. Their long-term goal is to reduce their carbon footprint to zero.

Richard points out that "one of the toughest things about living remotely is finding a path to right livelihood. A lot of folks starve out and head back to the city." Karen chimes in and humbly voices her satisfaction with the life they lead: "What a joy to be able to help others on their own path to clean energy, doing something that you believe in, while helping the planet too."

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